

THE
Young Gentleman's
ASTRONOMY,
CHRONOLOGY,
AND
DIALLING,

Containing such
ELEMENTS of the
said Arts or Sciences, as are most
useful and easy to be known.

By EDWARD WELLS, D. D.
Rector of Cotesbach in Leicester-
shire.

L O N D O N,
Printed for James Knapton, at the Crown
in St. Paul's Church-Yard. 1712.

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Tutor of Mathematics in Feinshar
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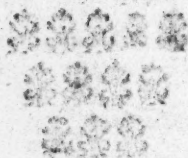


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THE
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By EDWARD D. D.
Rector of the School in Leicester
square.
**MUSEVM
BRITAN
NICVM**



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~~Students. It for those who are to~~
~~make their fortunes by their Learning.~~
~~more Particulars are requisite to be~~
~~known, and consequently more Time~~
~~is to be taken by such than~~
~~by others; and being done to the~~
~~Effect, are by their Learning not to~~
~~make but to add to their Fortunes.~~

THERE are two Ends of
 Writing Books, which relate
 to the several Parts of Learn-
 ing: one, to advance Learn-
 ing it self; the other, to assist Lear-
 ners.

In pursuance of the former, the Capa-
 ciousness of the Subject is chiefly to be
 considered; and nothing is to be omit-
 ted, which properly falls within the Com-
 pass of the Art or Science treated of.
 In pursuance of the latter, the Capaci-
 ties of the Learners are principally to
 be regarded; and notice is to be taken,
 not of whatever may be known or done
 by the Art or Science treated of, but
 only of what is most useful, and withal
 easy to be known.

Besides, Regard is to be had, as to
 the Capacities principally, so secondari-
 ly to the Circumstances of the Young
 [A 2] Students.

The Preface.

Students. As for those who are to make their Fortunes by their Learning, more Particulars are requisite to be known, and consequently more Pains are requisite to be taken by such, than by others; who, being born to plentiful Estates, are by their Learning not to make, but to adorn their Fortunes already made.

And there is the more Need of this distinct Consideration, because one of the first Things Young Gentlemen become sensible of, is this; that they are not under a Necessity of taking Pains for their Livelihood. Which has such an Influence upon them, as that they are apt not to relish any Part of Learning, which requires more than ordinary Pains or Application of Mind. And indeed to expect they should act otherwise, is in effect no other, than to expect gray Hairs upon young Heads.

Wherefore, the most proper Method to make Young Gentlemen Learned, is this; to teach them at first only such Elements of the liberal Arts or Sciences, as are most useful in the common Affairs of Life, and withal most easy to be known. They have a competent Apprehension of the Usefulness of such Things

The Preface.

Things as occur in the common Concerns of Life; and consequently hereby that Question frequently put by Young Students, of what Use is this, will be answered afore-hand, and so they will be rendered willing to understand where they apprehend the Use of. And when they find that the Understanding thereby carries in it no Difficulty, then they will be also encouraged to proceed, and when they have thus gone through, and become Masters of the most useful and easy Elements of the liberal Arts and Sciences, they will thereby be enabled with much more Ease to conquer the more difficult Parts of Learning, if their own Inclinations shall lead them thereto hereafter, when they are come to Riper Years, and so can judge more rightly of the worth of Learning.

On these Considerations, and with this View, it was, that I drew up this Astronomical Treatise, and gave it the Title of the Young Gentleman's Astronomy: Such Astronomical Treatises as were afore extant among us; either treating only of the Doctrine of the Sphere or Globe, or else taking in several Particulars of the other Part of Astronomy,

The Preface.

some, too difficult for, and not necessary to be known by Young Gentlemen.

It only remains to be observed, that I suppose Young Gentlemen to proceed regularly in their Studies, and therefore to have learned Arithmetick and Geometry, before they enter upon Astronomy: or also, that such Particulars, as were not necessary to my present Design, and yet seemed too material to be quite omitted; I have added by way of Annotations, both in this Treatise, and the others of Chronology and Dialling.

~~CHAP. VIII. Of the Phenomena of~~

~~CHAP. VII. Of the Phenomena of~~

~~CHAP. VI. Of the Phenomena of~~

~~CHAP. V. Of the Phenomena of~~

~~CHAP. IV. Of the Phenomena of~~

~~CHAP. III. Of the Phenomena of~~

~~CHAP. II. Of the Phenomena of~~

~~CHAP. I. Of the Phenomena of~~

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ERRATA to the Young Gentleman's Astronomy.

PAGE 2. Line 7. For *move, themselves:* Read *move themselves.* p. 48. l. ult. f. from m. r. from M.
p. 68. l. 14. f. in Fig. 8. r. in Fig. 18. p. 73. l. 11.
f. Orbit. T 3. r. Orbit T 3. Ibid. l. 17. f. in DET.
r. in DEF. p. 87. l. 26. f. ial. Point. r. Equinoctial
Point. p. 104. l. 32. f. *either* 32. r. *either* 34.
p. 105. l. 16. f. at S. r. at 4. p. 129. l. 12. f. 15
Degrees. r. 51 Degrees.

ERRATA to the Young Gentleman's Dialling.

PAGE 38. Line 6. Read Fig. 13. p. 44. l. 47. f.
Substyle C. S. l. 29. r. Point m. p. 46. l. 15. 16.
r. Art or Science.

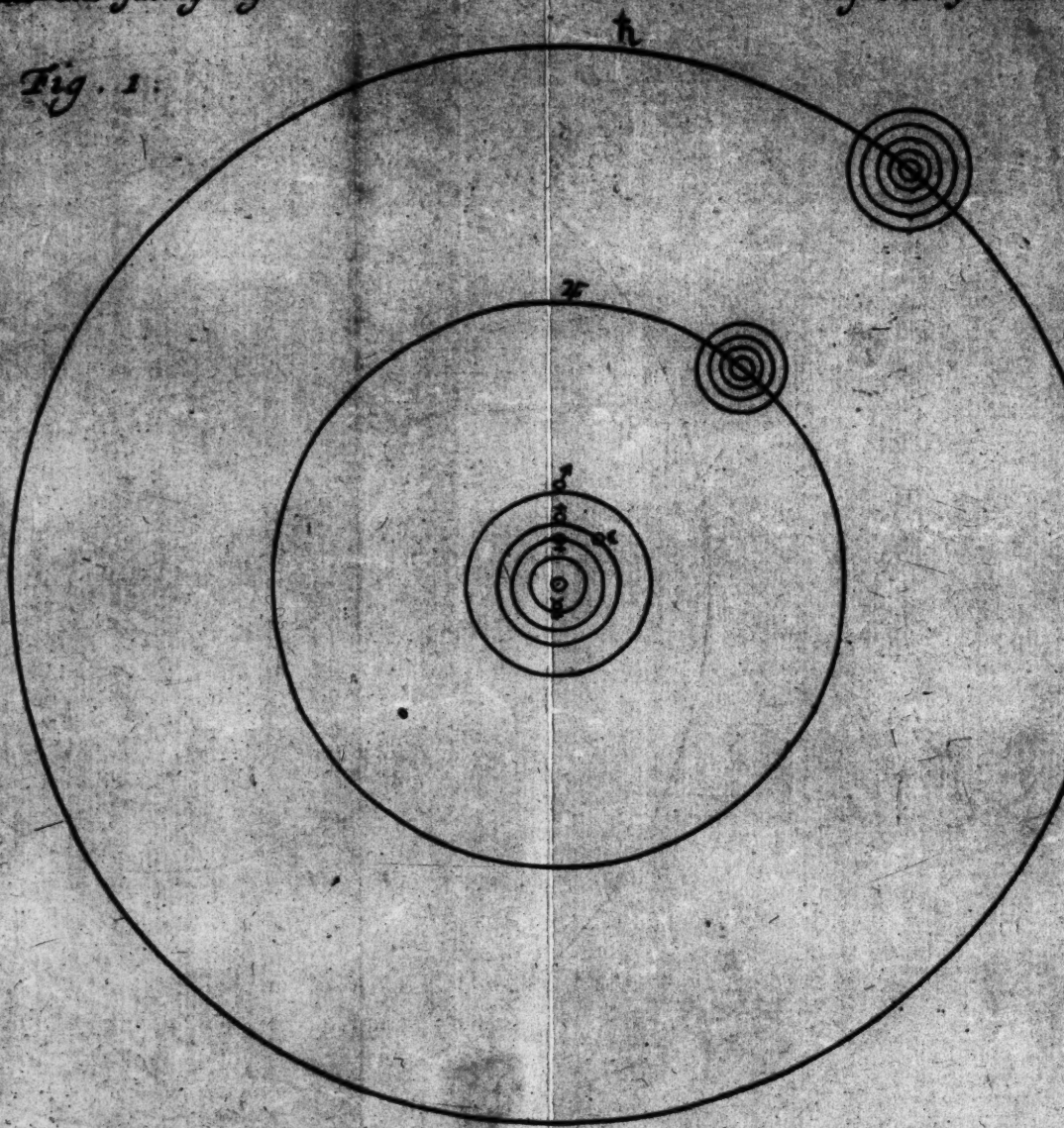
ERRATA to the Young Gentleman's Chronology.

PAGE 37. Line 23. Read, *every 19th Year.* p. 43.
l. 1. r. *very* improperly. p. 63. l. 26. r. Rome is
said (by some) to be built. l. 28. r. and thereto I add.
It is to be noted, that the different Accounts of the
Building of Rome before Christ, pag. 58, and 66. are
occasioned by the different Opinions of Writers,
(some placing the Building of Rome in the 3d, some
in the 4th Year of the 6th Olympiad,) and also from
the different Computation of the Terms of the said
Interval, some computing one or both Terms inclu-
sively, some exclusively.

Place this facing Pag. 1.

Astronomy. Plate

Fig. 1:



Platt 1.



THE
Young Gentleman's
ASTRONOMY.

The INTRODUCTION.

WE are informed by *Moses* in his Sacred History of the Creation, that God made Lights in the (*) wide Space of Heaven, to give Light upon the Earth, and to divide the Day from the Night, and to be for Signs and for Seasons, and for Days and Years, Gen. I. 14.—18.

I.
The Celestial Lights made to what Ends,

(*) So the Hebrew Word *Rakiah* truly signifies. It is rendered in our English Bible the Firmament, in Conformity to the Septuagint Version.

[B]

The

2. The principal Way, whereby the All-wise Creator of the World has rendered the Celestial Lights subservient to the fore-mentioned Ends, is by certain established Laws of *Motion*; according to which, they either *really* move, themselves, or at least *seem* to us to move.

The Celestial Lights are made subservient to the Ends, for which they were created, principally by Motion.

3. What these Laws of Motion are, the Divine Wisdom has not thought fit to reveal unto us. Wherefore, all that we can do, is to make probable Conjectures concerning them. Such Conjectures are termed (†) *Hypotheses*, i. e. Suppositions; because it cannot be positively affirmed of the most probable Conjecture, that the Celestial Lights do so move; but only, that it is reasonable to *suppose*, they move so, rather than any other Way; and that upon such a Supposition, their (||) *Phænomena* (or Appearances) may be rationally solved or explained.

We can only make probable Conjectures concerning the Laws of their Motion; which Conjectures are called Hypotheses, and why.

4. The Explanation of these Hypotheses, and the Solution of the Ce-

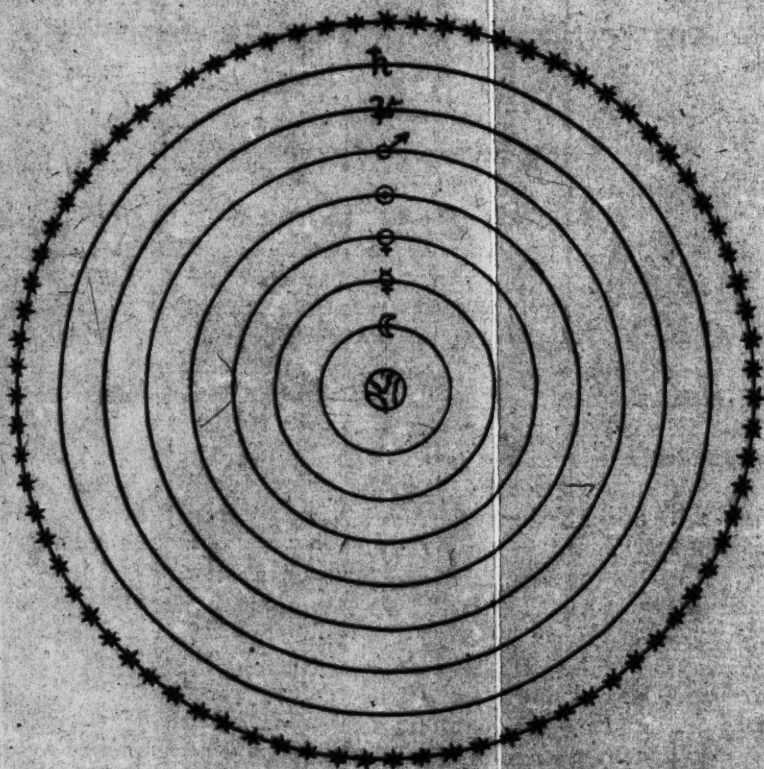
Astronomy, what.

(†) It is a *Greek* Word, derived from the Verb *ὑποτίθημι* to *suppose*.

(||) It is a *Greek* Word also, derived from the Verb *φαίω* to *appear*.

Place this facing Pag. 3.

Fig. 2.



lestial *Phænomena* thereby, is what makes up the Science called (*) *Astronomy*: which is a *Greek* Word originally, and denotes in that Language the Doctrine or Knowledge of the *Laws*, or of the *Distribution* and *Situation* of the Stars, or Celestial Lights.

There are four more remarkable Hypotheses, the (†) *Ptolemaick*, the *Copernican*, the *Tychonick*, and the *Semi-tychonick*. Of these the *Coperni-*

5.
The *Copernican Hypothesis*, why the most Probable.

(*) This Word may be derived, as to its latter Component, either from νόμος a *Law*, or from τόπος a *Distribution*, *Seat*, or *Situation*.

(†) The *Ptolemaick Hypothesis* is so called from *Claudius Ptolemaus*, a famous Mathematician of *Pelusion* in *Egypt*, who lived in the former Part of the second Century after Christ, under the Roman Emperours *Adrian* and *Antoninus Pius*. He writ both of *Astronomy* and *Geography*; and by his Astronomical Writings was conveyed to succeeding Ages, the Hypothesis which goes under his Name, and which was generally, not to say universally, received in these Parts of the World till the Days of *Copernicus*. The Order of the Celestial Lights as to their Situation, according to this Hypothesis, is represented *Fig. 2*. But since by the Help of *Telescopes*, the Phases of *Venus* and *Mercury* have been discovered, this Hypothesis is rejected, as not consistent therewith. I pass by the *Epicycles*, and several other Particulars justly blameable in this Hypothesis.

Copernicus, who was Born in 1473 at *Thorn*, a Town of Polish *Prussia*, perceiving the several Exceptions,

The Introduction.

can is now generally received by the more learned in *Astronomy*, as the most probable Hypothesis : forasmuch as it not only agrees with the Celestial *Phænomena*, but also explains the Motions

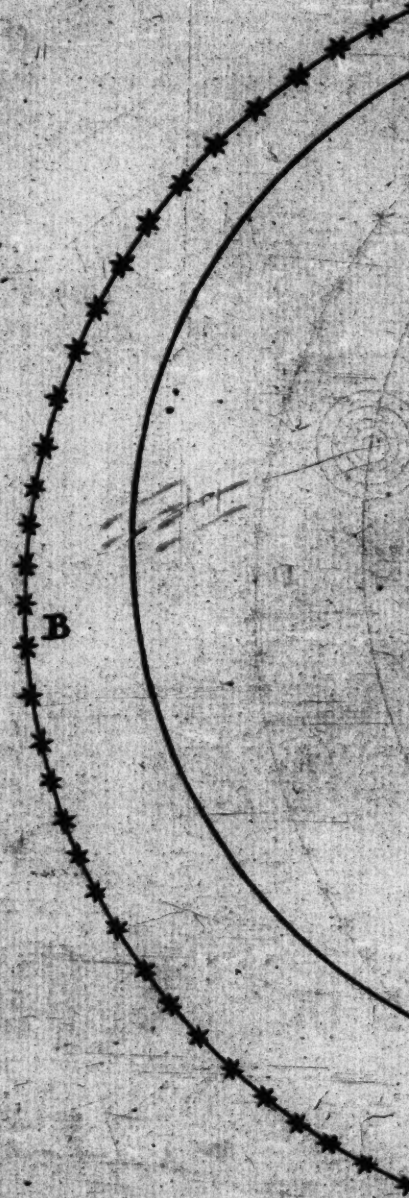
that the *Ptolemaick* Hypothesis was justly liable to, not only revived the old Hypothesis of *Philolaus*, (which Cardinal *Cusa* had moved and defended sometime before him,) but also went so far as to illustrate how the Celestial *Phænomena* might be very well solved thereby ; insomuch that this Hypothesis began presently after to be embraced by many, if not by most, of the more Learned *Astronomers*, and from the principal Reviver of it, *Copernicus*, to be called the *Copernican* Hypothesis. The Explication of this takes up great Part of this Treatise. To this belongs *Fig. 1.*

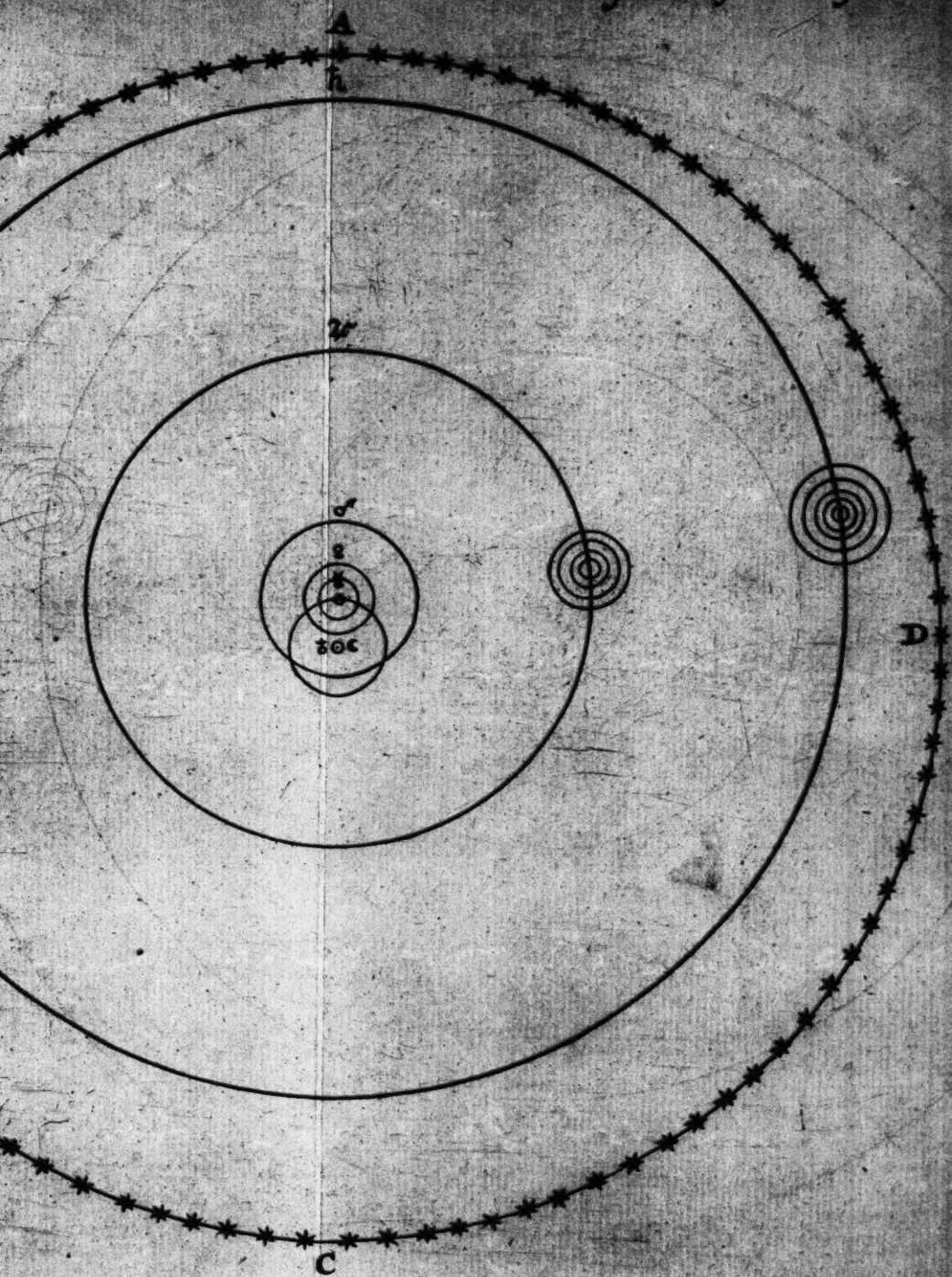
The *Tychonick* Hypothesis is so called from *Tycho Brahe*, a noble *Dane*, who lived in the latter Part of the sixteenth Century, and is famous for his Astronomical Observations at *Uraniburg*, (a Castle built by him in the Island *Weer* or *Huena* in *Denmark*, and by him called by this Name, as importing the *Tower* or *Castle of Heaven*.) This great Person and Astronomer, though he approved of the *Copernican* Hypothesis in rejecting the *Epicycles*, and other superfluous and erroneous Particulars of the *Ptolemaick* Hypothesis, yet could not reconcile himself to the Motion of the Earth, and the Sun's standing still, both asserted by *Copernicus*. Hereupon he set himself to contrive a new Way for solving the Celestial *Phænomena*, whereby he might avoid what was culpable in the *Ptolemaick* Hypothesis, and yet still retain the Motion of the Sun round the Earth, as round the Center of the World. To this his Hypothesis appertains, *Fig. 3.*

The *Semi-tychonick* Hypothesis is so stiled, as agreeing with the *Tychonick*, excepting only in this, that, whereas

Place this facing Fig. 4.

Fig. 3.





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The Introduction.

tions whence the said *Phænomena* arise, after the most (||) simple and uniform Manner, and consequently after such a Manner, as is most agreeable to the infinite Wisdom of the Creator. I proceed therefore to shew, how the Celestial *Phænomena*, at least the more remarkable of them, may be solved according to this Hypothe-

whereas the *Tychonick* makes the Earth to have no Motion at all, the *Semi-tychonick* makes it to move round its own *Axis*, and so agrees therein with the *Copernican*. But though the *Tychonick* and *Semi-tychonick* Hypothesis were both designed as Corrections of the *Copernican*, yet the Generality of the more Learned in *Astronomy* do still prefer the *Copernican* as the most probable, and that for the Reason above-mentioned in short, and to be more largely insisted on and explained in the Annotations next following,

(||) These two Propositions, *viz. Frustrâ sit per plura, quod fieri potest per pauciora*; and *Natura nihil agit frustrâ*, being so evident to Reason, as by Logicians and Philosophers to be esteemed *Axioms*, i. e. unquestionable Truths; it hence follows, that That Hypothesis is to be esteemed most agreeable to the Wisdom of God, the Author of Nature, which explains the Motions whence the Celestial *Phænomena* arise, after the most simple (or uncompounded) and uniform Manner; that is, which adjusts the said Motions to the fewest Laws and Principles. But herein the *Copernican* Hypothesis excels all the rest, forasmuch as according thereto, all the Bodies, on whose Motion depend the Celestial *Phænomena*, are retained in their proper *Orbits* by the single Principle of Gravity, and move in their *Orbits* according to one general Rule, or Law of Motion. Of which see more in Chap. 1.

[B 3]

fit,

The Introduction.

sis. And in order hereunto it will be requisite to begin with laying before the Reader the *Copernican* (*) *System*, i. e. in what Order the several Bodies, whereon depend the Celestial *Phænomena*, are placed with Respect one to the other, according to this Hypothesis.

(*) The Word *System* is borrowed from the Greek Tongue, wherein it denotes that Frame or Model which arises from placing several Things together, it being a Derivative of the Verb *ovvismu* to put or place together.

CHAR.

CHAPTER I

Of the Copernican System in general.

THE Copernican System is represented, Fig. 1. where the Sun is placed in the Center, and supposed never to move out of it, but only to move therein round its own (*) *Axis*, from West to East, in the Space of about 25 Days. This Motion of the Sun round its *Axis* is inferred from the Observations made of the Spots of the Sun.

Round the Sun, as the Center of their *Orbits*, move six Spherical Bodies in this Order and Time, viz. *Mercury* next to the Sun, in about three Months; *Venus* next to *Mercury*, in about seven Months and an Half; after that the *Earth* in a Year; then *Mars* in about two Years; then *Jupiter* in twelve Years; and outermost

The Place of the Sun,

2.
The Places of Mercury, Venus, the Earth, Mars, Jupiter, and Saturn; and their Periodical Times.

(*) See Chap. 3. Sect. 5. and the Note there.

of all *Saturn* in about thirty Years. These are respectively denoted, *Fig.* 1. by their proper Characters.

3.
Of the
Moon, and
the Satel-
lites of
Jupiter
and *Sat*
turn.

As the fore-mentioned six Bodies move round the *Sun*, so round three of them move other Bodies; *viz.* round the *Earth* moves the *Moon* in about 27 Days, 8 Hours; round *Jupiter* move four, and round *Saturn* move five Bodies, called respectively the (†) *Satellites* of *Jupiter* and *Saturn*. Of the *Satellites* of *Jupiter*, the innermost moves round *Jupiter* in 1 Day, 18 Hours; the second in 3 Days, and a little more than Half a Day; the third in 7 Days, 4 Hours; the fourth and outmost in 16 Days, 18 Hours. Of the *Satellites* of *Saturn*, the inmost moves round *Saturn* in 1 Day, 21 Hours; the second in 2 Days, 18 Hours; the third in 4 Days, and a little more than half a Day; the fourth in almost 16 Days; and the fifth in 79 Days, 8 Hours.

(†) They are so called, as attending *Jupiter* and *Saturn*, as a Prince is attended by his *Satellites* or Life-guard.

All the Bodies afore-mentioned, except the *Sun*, are called (||) *Planets*, (which Word in the *Greek Language* denotes *Wanderers*) forasmuch as never keeping for any Time the same Distance or Situation one to the other, they may be said to be always Strag-
gling or *Wandering* from one another. And because the *Moon* and the *Satel-
lites* of *Jupiter* and *Saturn* are Planets of Planets, hence they are distinguish-
ed by the Name of *secondary Planets*, and the other six Planets agreeably thereto, are distinguished by the Name of *primary Planets*.

4.
Planets
why so cal-
led, and
why distin-
guished in-
to Primary
and Se-
condary.

The Distance of the primary Pla-
nets from the *Sun*, is much the same as is expressed, *Fig. 1.* For dividing the Distance of the *Earth* from the *Sun* into ten Parts, the Distance of *Mercury* from the *Sun* is almost four such Parts, of *Venus* seven, of *Mars* fifteen, of *Jupiter* fifty-two, and of *Saturn* ninety-five.

5.
The Di-
stance of
the pri-
mary Pla-
nets from
the *Sun*.

(||) Whereas the Planets are commonly reckoned seven, this is according to the *Ptolemaick System*, *Fig. 2.*

And

6.
The Distance of
the Secondary Planets from
their Primary.

And as to the Distance of the secondary Planets from their primary respectively, it is esteemed to be such as this; viz. the Distance of the Moon from the Earth to be about 60 Semi-diameters of the Earth. The inmost *Satelles* of *Jupiter* is esteemed to be distant $5\frac{1}{2}$ Semi-diameters of *Jupiter* from the Center of *Jupiter*; the second *Satelles* is esteemed to be distant 9 of the same Semi-diameters; the third $14\frac{1}{2}$ such Semi-diameters; and the fourth $25\frac{1}{2}$ Semi-diameters. In like manner the Distance of the inmost *Satelles* of *Saturn* from the Center of *Saturn* is reckoned to be $4\frac{1}{2}$ Semi-diameters of *Saturn*; the distance of the second to be $5\frac{1}{2}$ such Semi-diameters; of the third, 8 Semi-diameters; of the fourth, 18; of the fifth, 54 Semi-diameters of *Saturn*.

7.
The Motion of all
the Planets is regulated
after an uniform
Manner.

The Reason of taking such particular Notice of the Distance of the primary Planets from the Sun, and of the Secondary Planets from their respective Primary, is this, viz. because these several Distances (as well as the several Times, wherein the Planets, whether Primary or Secondary, move round their respective *Orbits*, and which

which are therefore stiled their *Periodical Times*) are requisite to be known, for the apprehending the Excellency of the *Copernican System*; according to which the Motion of all the Planets, both Primary and Secondary, are regulated by one general Law, which is this:

The Squares of the Periodical Times of the { Primary } Planets are one to another, as the Cubes of their Distances from the { Sun. } Center of the Primary.

Thus for Instance as to the primary Planets, the Period of *Saturn* is (round) 30 Years, of *Jupiter* 12; the Squares of which Numbers are 900 and 144. The Distance of *Saturn* from the Sun is found by Observation to be to the Distance of *Jupiter* from the Sun as about (*) 9 to 5, the Cubes of which are 729 and 125. But the Squares 900 and 144 are very nearly in the same Ratio, as the Cubes 729 and 125. And the Ratio in this and

8. The same exemplified as to the primary Planets:

Square of Times of Revolution of two Planets, Cube of the Distances.

Eq^d Numbers produced will be in y^e same Ratio.

(*) Namely the Distance of *Saturn* (as is above observed) from the Sun is 95, and of *Jupiter* 52, both Distances being measured by the same Measure.

the following Instances would be found more exact, were the Periods and Distances more exactly expressed by Numbers. In like manner the Period of the Earth is a little more than four Times greater than the Period of *Mercury*; and so the Squares of the Numbers expressing those Periods will be almost as 17 and 1. And the Distance of the Earth from the Sun being divided into ten Parts, the Distance of *Mercury* from the Sun is found by Observations to be (little less than 4 such Parts, viz.) 3 such whole Parts, and 9 Tenths of another, the Cubes of which Numbers (viz. 10 and $3\frac{9}{10}$) are 1000 and 59. But it is obvious, that 17 is to 1, much as 1000 to 59. And so of the other primary Planets.

9.
And also
as to the
secondary
Planets.

As for the secondary Planets, the Periodical Times of the *Satellites* of *Jupiter* are (as is above observed) respectively as $1\frac{3}{4}$, $3\frac{3}{5}$, $7\frac{1}{8}$, and $16\frac{3}{4}$, and their Distances are as $5\frac{1}{4}$, 9, $14\frac{1}{4}$, and 25. But the Square of the Periodical Time of the innermost *Satelles*, namely 3, is to 13 the Square of the Periodical Time of the second *Satelles*, as 170 the Cube of the Distance of the

the innermost from the Center of *Jupiter*, to 736 the Cube of the Distance of the second from the same Center. Likewise 3 is to 51 the Square of the Periodical Time of the third *Satelles*, as 170 to 2890 the Cube of the Distance of the third from the Center of *Jupiter*. And again 3 is to 280 the Square of the Periodical Time of the fourth and outermost *Satelles*, as 170 to 15800 the Cube of the Distance of the said outermost *Satelles* from the Center of *Jupiter*. And the same holds good as to the *Satellites* of *Saturn*. But as to the Moon, it is not applicable to her, forasmuch as she is the only secondary Planet, that moves about the Earth.

From what has been said, evidently appears, that the Periodical Motions of the Planets are performed uniformly, or are regulated by one general Law. And from hence it is demonstrated (†) by the Learned, that the Planets are likewise retained in their

10.
All the
Planets
retained in
their own
Orbits by
Gravity.

(†) See Dr. Gregory (late Savilian Professor at Oxford) his *Astron. Phys. and Geom. Elem. lib. 1. prop. 27, 28, 29. and Sect. 6. and 7.* I shall only observe here,

their proper *Orbits* after an uniform Manner, by one Sort of Force which makes them tend to the Center of their respective *Orbits*, and is thence called the *Centripetal Force*, or in one Word *Gravity*. And this is another Particular, wherein appears the Excellency of the *Copernican System* above any other; forasmuch as this System may be preserved by Gravity alone, uniformly propagated through the Universe, whereas (II) all the other Systems require some (one or more) other Force, besides that of Gravity.

II.
All the
Planets
receive
their Light
from the
Sun.

All the Planets, Primary and Secondary, are Opacous Bodies, i. e. such as have no Light of their own, but receive all their Light from the Sun; and so for this, as well as other Reasons, are accounted as so many Dependants of the Sun. Whence the

here, that any Body, when moved, will move uniformly in a straight Line, if not hindered. And agreeably any Planet would fly out of its *Orbit* into a right Line, which is a Tangent to its *Orbit*, was it not hindered or pulled back and retained in its *Orbit* by some Centripetal Force, i. e. by Gravity.

(II) See *Greg. Astron. Phys. and Geom. Elem.* pag. 111, 112.

Sun

Sun with these its Dependants make up what is called the *Solar System*; described, *Fig. 1.*

As for the other Celestial Lights, called the *Fixed Stars*, they are independent of the Sun, as in other Respects, so in respect of Light; forasmuch as they receive not their Light from the Sun, but shine with their own Native Light. Hence they are esteemed to be, not only without this our Solar System, but as so many Suns themselves, each being placed in the Center of some such System, as this our Solar System, and there so fixed, as to have no Motion, but round their own *Axis*. They are supposed to be vastly distant from this our Solar System; which is the Reason that their Distance is taken no Notice of in the Description of the *Copernican System*, *Fig. 1.*

12.
Of the
Fixed
Stars.

Besides the Celestial Lights already mentioned, there appear sometimes *Comets*; which is originally a Greek Word, denoting in that Language as much as *Hairy*. These Lights are called by the *Greeks*, *Hairy Stars*, because they fancied the Streams of Light, which attend such Stars, to resemble

13.
Of Co-
mets.

resemble Hair. It is found by Observations, that these Comets do (*) pass through the Planetary Orbs of this our Solar System ; but whether they depend only on the Sun, and so belong only to this our Solar System, or whether they move in Circular or such like Lines, or whether they are so much as durable Bodies, is not yet discovered. For which Reasons, there is no Notice taken of them, *Fig. 1.*

14.
The Orbits
of the Planets are
Elliptical.

Before we conclude this Chapter concerning the *Copernican* System in general, it seems proper to observe, that although the *Orbits* wherein the Planets move, are described, *Fig. 1.* as so many Circles, and may be well enough conceived as such in many Respects ; yet more strictly speaking, they are not exactly Circular, but Elliptical.

15.
Of the Zodiack and
Ecliptick.

Further it seems not improper to observe also here, that the fixed Stars being the most remote of all the Celestial Lights, and appearing to us as placed in one Concave Sphere ; hence it is usual to denote the *Place* of any

(*) Hence the Line Comet describes by its Motion is called its *Trajectory*.

System in general.

57

of the intermediate Celestial Lights,
by assigning what Part of the Sphere
of the fixed Stars they appear to us
to be in, or more properly under.
and accordingly it is usual to distin-
guish that Tract of the Sphere of the
fixed Stars, under which all the Pla-
nets do move, by the Asterisms or
constellations that lie in that Tract;
which being fancied to represent se-
veral Things, are therefore called
signs; and because the Things repre-
sented by them are most of them (*†*)
Vegetables, or *Animals*, hence all this
Tract is stiled the *Zodiack*. Now the
Orbit, wherein the Earth performs
her Annual Period (and which the Sun
seems to move round every Year)
is under the very Middle of the
Zodiack; whence this middle Part of
the *Zodiack* is of special Note in *A-*
stronomy, and is therefore distinguish-
ed by a peculiar Name, being called
(II) *Ecliptick*. It, as well as the
whole *Zodiack*, is divided into twelve

(I) It is a Greek Word signifying *Animals* or *Li-*
creatures.

The Reason of this Name. See Chap. 4. Sec. 8.

[C]

Parts,

Parts, distinguished by the Name of the Constellation or Sign, to which each Part was formerly assigned. The (*) Names of the said Signs, together with the Characters whereby they are denoted in short, are as follows, viz.

 *Aries*,  *Taurus*,  *Gemini*,  *Cancer*,  *Leo*,  *Virgo*,
 *Libra*,  *Scorpio*,  *Sagittarius*,  *Capricornus*,  *Aquarius*,  *Pisces*.

16.
Of the
Nodes of
the Planets.

Lastly, It seems proper here to observe, that the Planets do not move in Orbits, which exactly run one over the other, or are all contained in the same Plane; but their Orbits do cross one another according to several Degrees of Inclination, of which the same, the Planes of their Orbits are variously inclined one to the other. Now the Earth being that Planetary Body we live on, hence the Plane of the Orbit of the Earth is taken by Astronomers for the Standard; and the Inclination of the Planes of the

(*) The Names of the Signs are somewhat differently expressed in these two memorial Verses, viz.

Signa Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Arcitenens, Caper, Amphora, Pisces.

Orbits of the other Planets is reckoned greater or less, as the said Planes incline more or less in respect to the Plane of the Earth's *Orbit*, or (†) (which comes to the same) to the Plane of the *Ecliptick*. The two Points, wherein the *Orbit* of any Planet crosses the *Ecliptick*, are called the *Nodes* of that Planet. And thus much for the System of the World in general, and such Particulars as relate to it in general.

(†) For the *Ecliptick* is that Part of the Sphere of the fixed Stars, which the Plane of the Earth's *Orbit* produced thereto touches. So that the *Ecliptick* is no other than the Extremity of the Plane of the Earth's *Orbit*.

[C] H A P.

C H A P. II.

Of the Diurnal Phenomena common to the Celestial Lights.

I.
The Diurnal Phenomena are common to the Celestial Lights in general.

HAVING in the foregoing Chapter explained, so far forth as is sufficient to the Design of this Treatise the Copernican System in general, now proceed to explain agreeably thereunto the Phenomena of the Celestial Lights. I shall begin with explaining the Diurnal Phenomena common to them in general, viz. the Rising, Setting, &c.

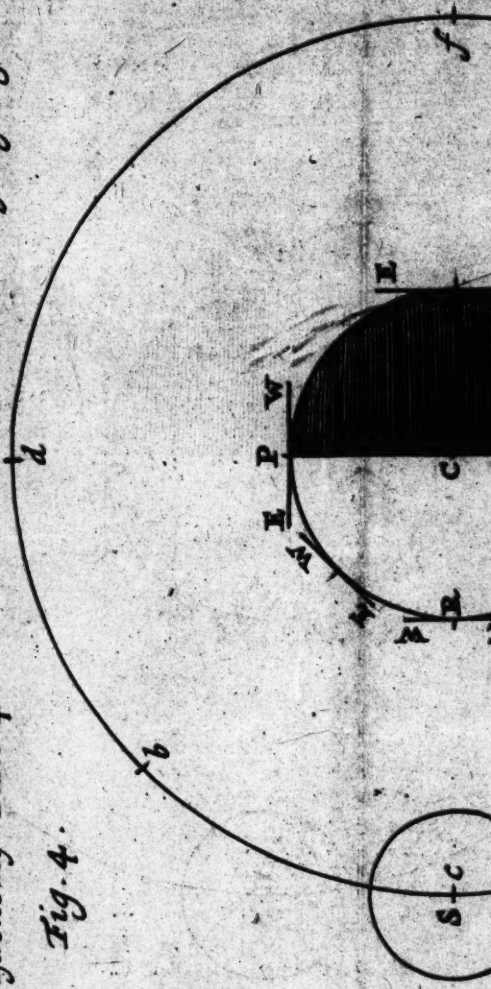
2.
They are to be solved by the Diurnal Revolution of the Earth.

Now these Diurnal Phenomena of the Celestial Lights may be solved by the Diurnal Revolution of the Earth, i. e. by one single Revolution of the Earth round its own Axis in 24 Hours. This is illustrated Fig. 1. where the Circle P R T H denotes the Earth; C the Center of the Earth through which passes perpendicularly its Axis, round which it makes its Diurnal Revolution. P denotes any Place on the Earth; the Line E V the

Astronomy Plate 4.

Place this facing Fig. 20.

Fig. 4.



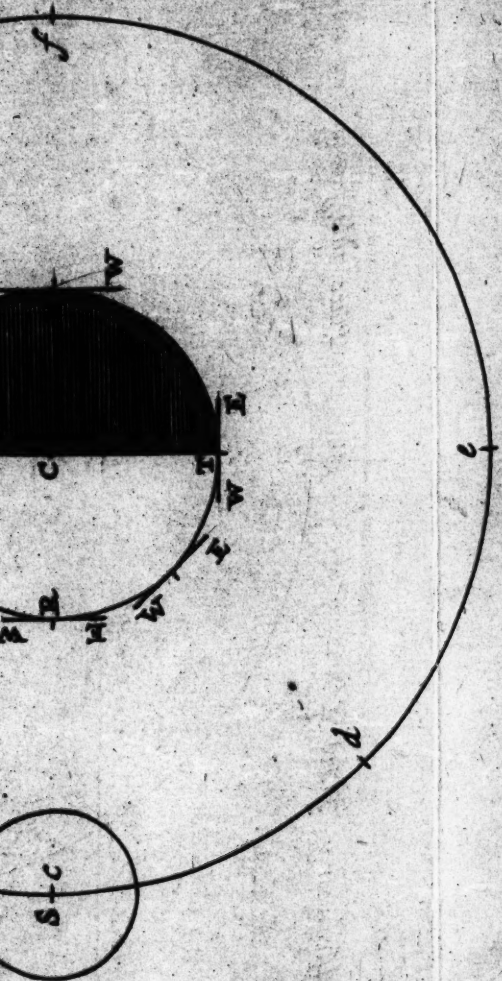
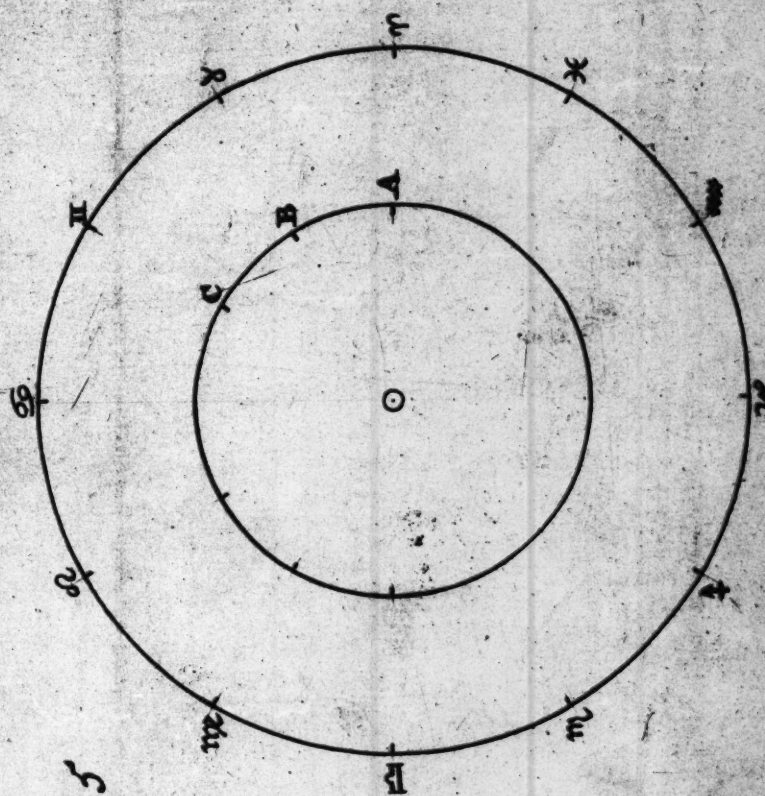


Fig. 26.

Fig. 5



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that Circle which bounds the Sight in the said Place, and is by Astronomers called the (*) *Horizon*; E the east Point of the said *Horizon*, W the West; the Circle *a b c d e f* denotes the Circumference of the Heavens; the Circle S the Sun in the Heavens; the Semicircle *P R T*, the enlightened Hemisphere of the Earth, or that Half of it which is opposite to the Sun; the Semicircle *P H T*, the darkened Hemisphere of the Earth. Now the Earth being supposed in this Situation, and also to move round its *Axis* towards the Sun; it is evident, that the Place P of the Earth will just begin to be enlightened by the Sun, and so the Sun will appear there to be just Rising, or ascending the *Horizon* at E the east Point of it. The Earth being moved round its own *Axis*, so as that the Place P of the Earth, which before was under the Point *a* in the Heavens, now is under the Point *b*; it is evident, that the *Horizon* of the said Place P, will be now so situated, as that the Sun will appear to a Spectator

(*) It is a Greek Word, denoting in that Tongue
anywhere that bounds.

atator at *B*, as ascended considerably
 above *E* the east End of the *Horizon*.
 And while, by the Revolution of the
 Earth round its *Axis*, the Place *P*
 passes from under the Point *b* in the
 Heavens to the Point *c*, the *Horizon*
 of the Place *P* will continually sink
 lower and lower in Respect of the
 Sun, and so the Sun will appear to
 ascend higher and higher, till *P* is
 come under *c*, where the Sun will ap-
 pear in its greatest Height above the
Horizon for that Day, and so it will
 be Noon or Mid-day at the Place *P*.
 For the Earth moving on, as the
 Place *P* passes from under *c* to *d*, the
 west Point of its *Horizon* will ascend
 higher and higher, and so the Sun
 will appear more and more to de-
 scend, as is represented by the *Horiz-*
on at the Point of the Earth under
d. The Place *P* being carried by the
Diurnal Revolution of the Earth from
 under *d* to under *e*, the Sun will then
 appear just on *W* the west Point of
 the *Horizon*, and so will appear to be
 just Setting. The Place *P* being come
 under *f*, it will be then Mid-night
 there. Lastly, the Place *P* being come
 round again under *a*, it will be then

Sun rising again: And thus it has been shewn, that the same *Diurnal Phenomena* of the Sun will come to pass, if the Sun stands still, and the Earth move round its own *Axis* from West to East, or from under *a*, to under *b*, *c*, *d*, &c. in the Heavens; as are commonly esteemed to come to pass by the Earth's standing still, and the Sun's moving round it from East to West, or from *e* to *h*, *i*, *f*, &c. And that the same holds good as to any other Celestial Light, and the Earth, is obvious to shew from Fig. 4, the Circle representing the Sun being taken to denote any other Celestial Light.

But now it being justly received by Philosophers as an unquestionable Truth, that Nature works after the most simple and compendious Manner; it thence follows, that the Solution of the *Diurnal Phenomena* by the Revolution of the Earth alone round its own *Axis*, is much more agreeable to Nature, than the Solution of the said *Phenomena* by the Revolution of all the several Celestial Lights round the Earth.

4
The Prob-
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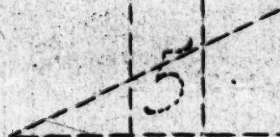
3.
The Prob-
ability of
the Coper-
nican Sy-
stem fur-
ther esta-
blished.

4.
The com-
mon and
proper
Motion of
the Celesti-
al Lights,
what.

It remains only to observe, that whereas by the *Diurnal Revolution* of the Earth, all the several Celestial Lights seem to move in the Heavens from East to West, hence the seeming *Diurnal Motion* of the Celestial Lights is called their (+) *common Motion*, as being common to all of them. Besides which all the Celestial Lights, but the Sun, have *proper Motion*; from which arise the *proper Phenomena*. As for the *proper Phenomena* of the Sun, they likewise seem to arise from the *proper Motion* of the Sun, but are really produced by another Motion which the Earth has, and whereby it moves round the Sun once every Year, whence it is called the *Annual Motion*.

(+) The *Diurnal Motion* is also called *Motus Primus*, either because it is usually first created of itself, or because it is supposed according to the *Ptolemaick System* to be caused by the *Primum Mobile*, which according to the said System is a Sphere above the fixed Stars, carrying all the Celestial Lights along with it from East to West. Whence the said *Diurnal Motion* is also called sometimes *Raptus*. In like manner the *proper Motion* is likewise styled *Motus Secundus*, in Contradistinction to the *Diurnal Motion* called *Motus Primus*.

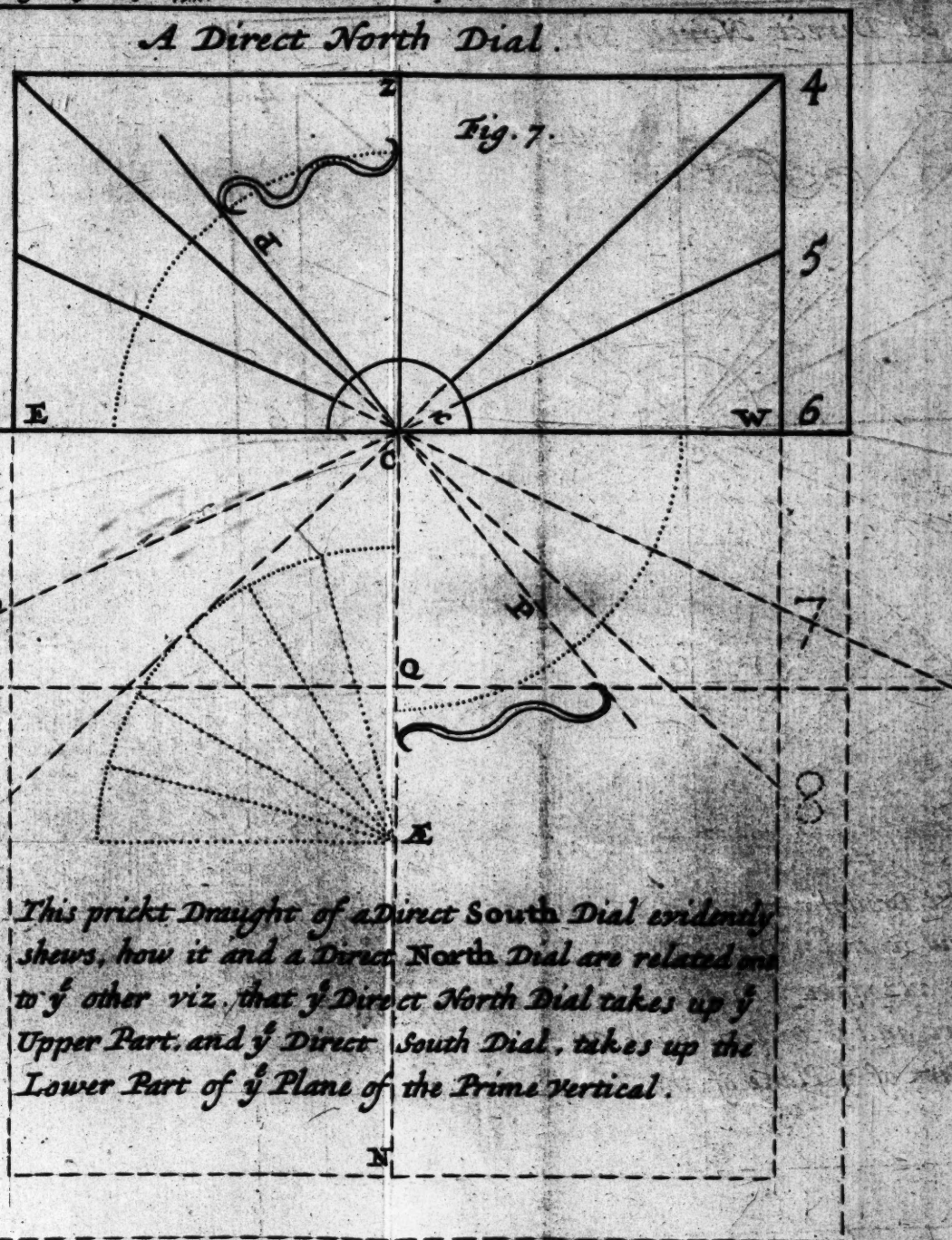
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4

This
show
to y^e
Upper
Lower

A Direct North Dial.



This prickt Draught of a Direct South Dial evidently shews, how it and a Direct North Dial are related one to y^e other viz. that y^e Direct North Dial takes up y^e Upper Part, and y^e Direct South Dial, takes up the Lower Part of y^e Plane of the Prime Vertical.

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of the Earth. Having therefore explained in this Chapter the Diurnal and common Phenomena of the Celestial Lights, I proceed to explain their proper Phenomena.

As to the seeming Annual Motion of the Sun, (but rather depending on the real Annual Motion of the Earth.

Being to explain in the next Place the Phenomena proper to the several Celestial Lights, I begin with the proper Phenomena of the Sun, inasmuch as the Sun is the principal Light of that System of the World, wherein we are placed.

Now these Phenomena of the Sun, which are vulgarly ascribed to the seeming Annual Motion of the Sun, may be solved by the Annual Motion of the Earth. In order whereunto it is first to be shewn, that the Annual Motion of the Earth will cause the Sun to appear to us, as if it had such an Annual Motion, though it really has no such Motion. And this is illustrated Fig. 5. where the Sun is in

The proper Phenomena of the Sun, explained.

The seeming Proper or Annual Motion of the Sun is caused by the real Annual Motion of the Earth.

of the Earth. Having therefore explained in this Chapter the several and common Phenomena of the Celestial Lights, I proceed to explain their

CHAPTER III.

Of the Phenomena (commonly ascribed to the seeming Annual Motion of the Sun, but rather depending on the real Annual Motion of the Earth.

1. The proper Phenomena of the Sun, why first explained.

BEing to explain in the next Place the Phenomena proper to the several Celestial Lights, I begin with the proper Phenomena of the Sun; forasmuch as the Sun is the principal Light of that System of the World, wherein we are placed.

2. The seeming Proper or Annual Motion of the Sun is caused by the real Annual Motion of the Earth.

Now these Phenomena of the Sun, which are vulgarly ascribed to the seeming Annual Motion of the Sun, may be solved by the Annual Motion of the Earth. In order whereunto it is first to be shewn, that the Annual Motion of the Earth will cause the Sun to appear to us, as if it had such an Annual Motion, though it really has no such Motion. And this is illustrated Fig. 5, where the Sun is in the

the Center, the Circle next round it denotes the *Orbit* of the Earth, or that Circular Line which the Center of the Earth describes by its Annual Motion; the outermost Circle denotes the *Ecliptick*, distinguished into its 12 Parts or Signs. Now supposing the Earth to be at A, the Sun will appear to us to be at ϵ ; and supposing the Earth to move from A to B, and so to C, the Sun will thereby appear to us to move from ϵ to η , and thence to ζ . And in like manner, by the Earth's Motion along the Rest of its own *Orbit* till it comes to A again, the Sun will seem to us to move along the Rest of the *Ecliptick* till it comes to ϵ again. 'Tis evident then, that, supposing the Earth to move as has been here described, the Sun, though it really stands still, will seem to have the same Annual Motion along the *Ecliptick*, as it would have, if it really moved so, and the Earth stood still.

Only 'tis remarkable, that whereas we commonly say, *the Sun is in Aries*, when it is between us and Aries, (and so of any other Sign,) if we would speak properly, and agreeably to the natural

sun is not
such or
such a
sign.

the Sun
is not
such or
such a
sign.

Of the
Earth's
Axis and
Poles, as
they are
situated
in the
Heaven
An Obser-
vation as
to the com-
mon Way
of saying,
that the

Sun is in
such or
such a
Sign.

natural Cause of this (and such like Phenomenon, we should say, that Earth is then in *Libra*; forasmuch the Earth in its real Motion is always in the Point of the *Ecliptick* opposite to that, wherein the Sun appears to be.

4.
The Variety of the Seasons, &c. how to be solved by the Annual Motion of the Earth.

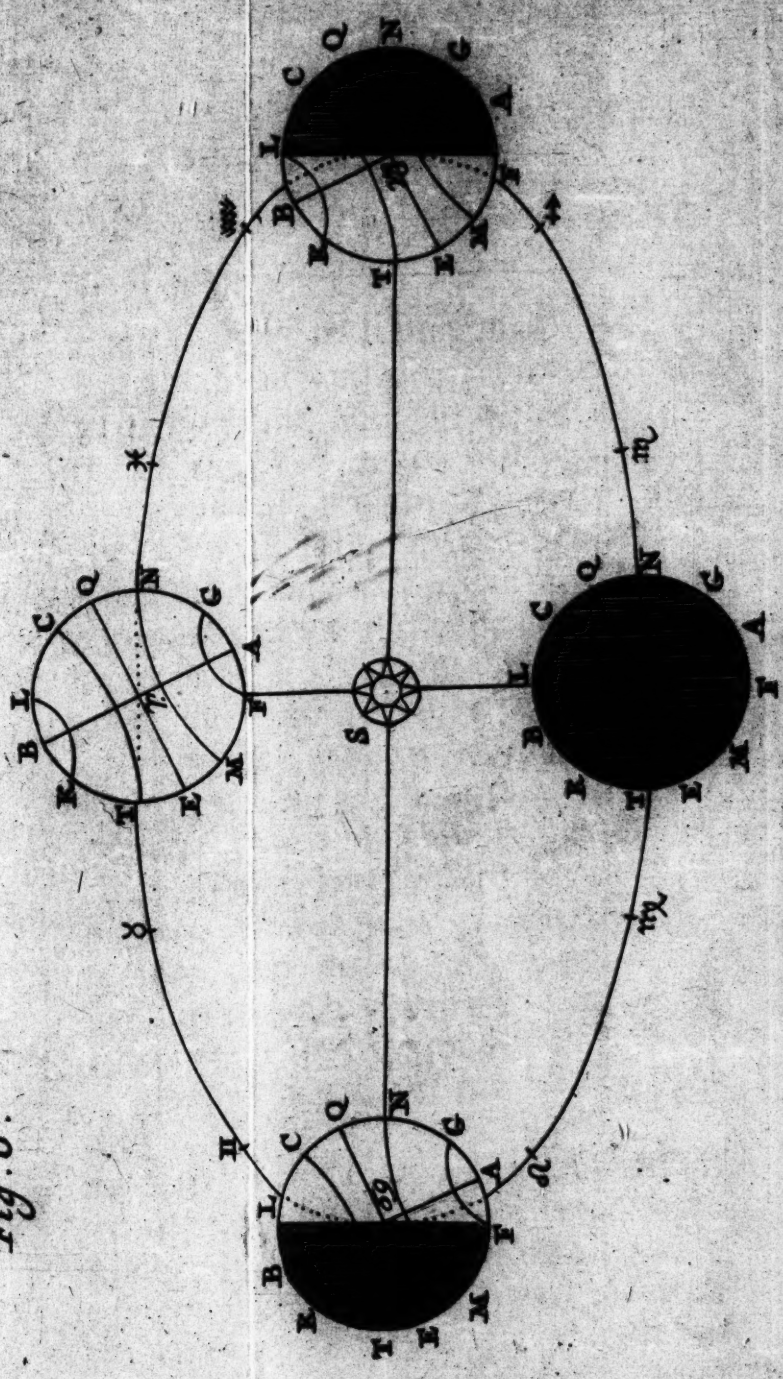
Having shewn that the Annual Motion of the Earth along the *Ecliptick* will make the Sun appear to us, as if it had such an Annual Motion, proceed now to shew, how the Variety of Days and Nights as to the Length, and the various Seasons of the Year, (all commonly ascribed to the seeming Annual Motion of the Sun,) may be solved by the Annual Motion of the Earth. And this is illustrated *Fig. 6*; for the clearer Understanding whereof there are two premised the following Particulars.

5.
Of the Equator, its Axis and Poles, as also of the Tropicks.

As the (*) *Axis* of the Earth (and so of the Sun, or any other Celestial Body) is, the very Mid-line of it, which consequently passes through its Center, and is represented, *Fig. 6*.

(*) The right Line, round which Bodies or Circles are conceived so move, are so called in Allusion to the *Axle* or *Axle-tree* of a *Chariot* or *Cart* wheel.

(where



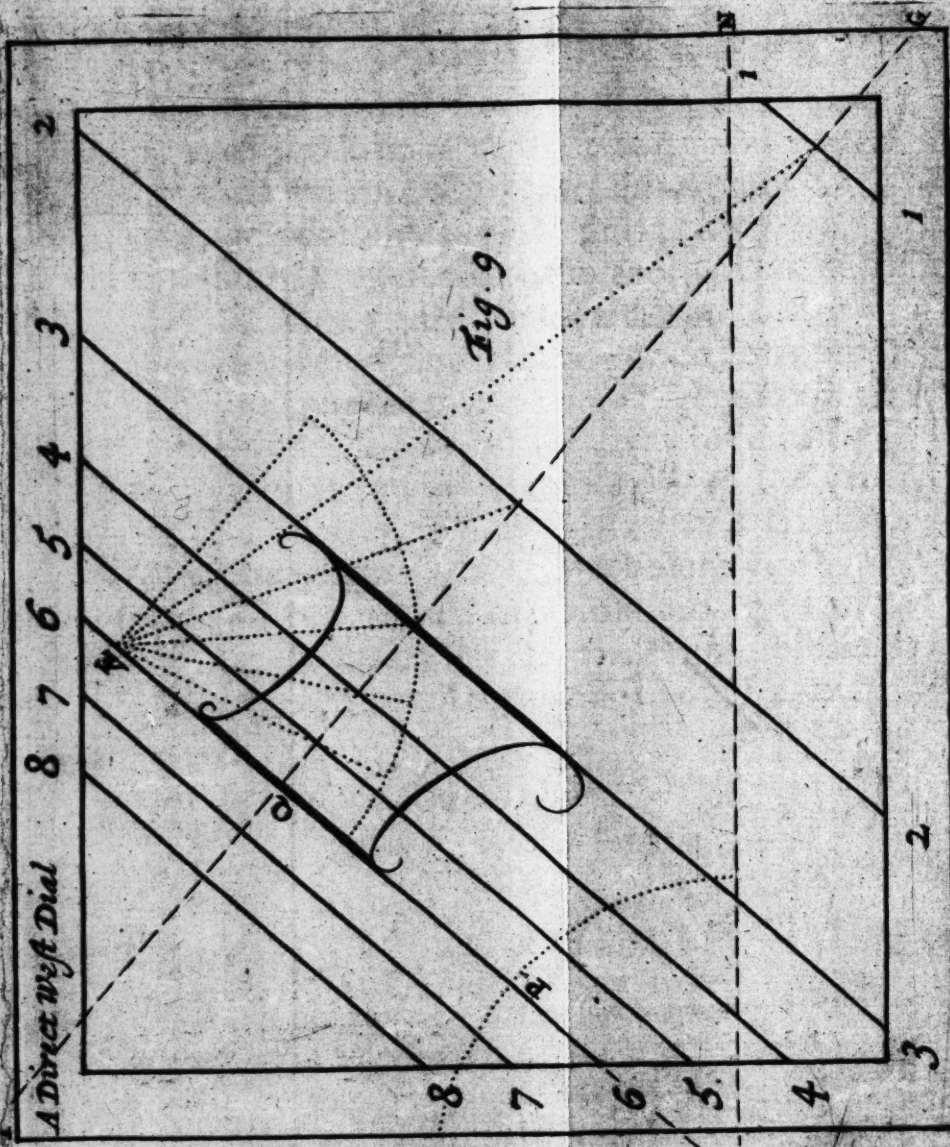
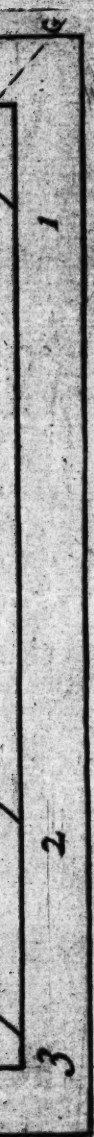


Fig. 29.
A. J.

s
c



where the Circle A.Q.B.E. represents the Earth, by the right Line A.B.; for the two Ends of any *Axis* are called *Poles*, and consequently the two Ends of the *Axis* of the Earth are called the *Poles* of the Earth; which always pointing one Northwards, the other Southwards, hence the former is called the *north Pole*, and is denoted, Fig. 6, by B; the latter is called the *south Pole*, and is denoted by A, between these Poles each Point of the Earth by its *Diurnal Revolution* does describe a Circle; of which that, which is in the very Middle between the Poles, and is the greatest, is called the *Equinoctial* or *Equator*, (denoted Fig. 6. by E.Q.) because when the *Sun* is in the Plane of this *Equinoctial* Circle, it is equal Day and Night all over the World. And did this Circle exactly answer to, or run along under the *Ecliptick*, there would be equal Day and Night throughout the Year all over the World. But the *Equator* crossing the *Ecliptick*, hence it is equal Day and Night only twice in the Year; namely, when the *Sun* appears in one of those two Points of the *Ecliptick*, where the

Polar Circles, Equinoctial Points, Solstitial Points, &c.

Equator

Equator crosses it, viz. in the first Degree of *Aries*, and the first of *Libra*; which are therefore called the two *Equinoctial Points*; and the Times of the Year answering thereto, the two *Equinox's*, one the *Vernal*, the other the *Autumnal*. Among the other Circles, which the several Points of the Earth by its *Diurnal Revolution* describe between the two Poles of the Earth, and which are all parallel to the *Equator*, there are four more remarkable, the two *Tropicks*, and the two *Polar Circles*. The two *Tropicks* are those Circles on the Earth which the *Sun* seems to go directly over, when it is at its greatest *Declination* or Distance from the *Equator*, either northward or southward. Whence one is called the *northern Tropick*, the other the *southern*. And because when the *Sun* appears to move vertically over the *northern Tropick*, he appears also to be in the Beginning of *Cancer*, hence the said *Tropick* is frequently stiled the *Tropick of Cancer*; and for the like Reason the *Southern* is otherwise stiled the *Tropick of Capricorn*. The Reason why both these Circles are called *Tropicks*

picks, is because the Sun appearing then at his greatest respective (northern or southern) Declination or Distance from the Equator, begins from thence presently to (†) turn back again towards the Equator. And because the Sun in the first Degree of Cancer and Capricorn does as it were make a Stand, going neither Northward nor Southward further from the Equator, hence these two Points of the Ecliptick are called the two Solstitial Points; and these two Times of the Year are called the two Solstices, one the Summer, the other the Winter. The Tropick of Cancer is represented, Fig. 6. by the circular Line T C, the Tropick of Capricorn by M N. The two Polar Circles are so called, either as being near to the two Poles of the Equator, or because they on the Earth answer to those Circles in the Heavens,

(†) The Greek Verb, *regho*, signifies to turn; whence is derived *regho*, denoting somewhat from whence a Turn is made.

(II) As every Point of the Earth by its real Diurnal Revolution, does really describe a Circle between the two Poles of the Earth; so the Sun, by its seeming Diurnal Revolution, does seemingly describe every Day

Heavens, which the (*) *Poles* of the *Ecliptick* seem to describe by the apparent *Diurnal* Motion of the Heavens. Hence these *Polar* Circles are just as far distant from their respective *Poles* of the *Equinoctial*, as are the *Tropicks* from the *Equinoctial*, viz. 23 $\frac{1}{2}$ Degrees, this being the Measure of the Angle, which the Planes of the *Equator* and *Ecliptick* make by their mutual Inclination. These *Polar* Circles do bound those Tracts of the Earth, where it is Day or Night during more or fewer whole *Diurnal* *Revolutions* of the Earth, or for any

Day a Circle, directly answering in the Heavens to that Circle on the Earth, to which the *Sun* is then Day Vertical. Hence there are usually conceived in the Heavens, *Equinoctial* and *Tropical* Circles, which directly answer to the like *Terrestrial* Circles.

(*) As the Earth, *Sun*, and all the other Celestial Bodies are said to have their respective *Axes*; so the Astronomical Circles (viz. *Ecliptick*, *Horizon*, &c.) are conceived by Astronomers to have their respective *Axes*; each of which is conceived to be a right Line passing through the Center of the said Circles, so as to be perpendicular to their respective Planes. And the Extremities of any such *Axis* is likewise called the *Pole* of the Circle, to which the said *Axis* belongs. And consequently (the *Axis* being always perpendicular to the Plane) the *Poles* of any Circle are always distant each 90 Degrees from the said Circle.

Hours

ours and upwards together. Of these Polar Circles, one is termed the *Arctick* or northern Polar Circle, being nigh the *Arctick* or north pole of the *Equator*, and the other for the like Reason is termed the *Antarctick* or southern Polar Circle. The former is denoted *Fig. 6*, by the circular Line *K L*, the latter by *F G*. It only remains to observe, that the *Sun* (or any other Celestial Light) will appear to be vertical to that Point of the Earth, where a right Line drawn from the Center of the *Sun* (or other Celestial Light) to the Center of the Earth, crosses the Surface of the Earth. Thus *Fig. 6*, when the Earth is in the Beginning of *Capricorn* or at *w*, the *Sun* will appear to be vertical to the northern Terrestrial *Tropic* *T C*, because a right Line drawn from *S* to *w*, will cross the Surface of the Earth at *T*. So when the Earth is at *v*, the *Sun* will appear vertical

The north Pole of the *Equator* is called other-
 the *Arctick*, because it is near the Constellations
 of the great and little Bears; the Greek Word
Arctos signifying a Bear; and hence the southern
 is stiled the *Antarctick*, as being opposite to the
Arctick.

to the Terrestrial Equator or *EQ* because a right Line drawn from *S* - *r* will cross the Surface of the Earth in a Point of *EQ*; for in this Position of the Earth the Line *S r* to be conceived perpendicular to the Axis *AB*. These Particulars being premised and apprehended, it will be easy to apprehend how the various Length of Day and Night, and the various Seasons of the Year are produced by the Annual Motion of the Earth.

6.

The Vernal Equinox explained by the Annual Motion of the Earth.

Suppose then the Earth to be at the *Sun* (as is afore observed, *S* 3.) will appear at *r*, and so in the Middle between the two Poles of Earth *A* and *B*; and consequently will enlighten from Pole to Pole that Hemisphere of the Earth which is opposite to it. Whence Half of the Terrestrial Equator *EQ*, and every Circle parallel thereunto, at that Time be enlightened by the *Sun*, and Half will be in the Dark. And consequently every Place of Earth (forasmuch as it lies either to the North or South of the Terrestrial Equator, or some Circle parallel to it) being carried round

Axis of the Earth in an uniform Manner by the *Diurnal* Motion of the Earth, will be as long in the Light, as in the Dark, i. e. the Day and Night will be then *equal* all over the Earth.

The Earth being moved by its *Annual* Motion from α to ϖ , the *Sun* appears then to us to be in $\mathfrak{z}$, where its greatest Declination northward, and the *Sun* being in this Situation, is evident, that the Rays of the *Sun*, which enlighten one Half of the Globe of the Earth at a Time, reach beyond the north Pole B to L, and the south Pole reach no further than F. Whence it follows, that the Tract of the Earth within the north Polar Circle K L, at this Time of the Year enjoys Day-light throughout the whole *Diurnal Revolution* of the Earth; and on the contrary, that it is continual Night throughout the whole *Diurnal Revolution* of the Earth, the Tract of the Earth lying within the south Polar Circle F G. It follows also, that the greater Portions of the Parallels to the *Equator*, which are between the *Equator* and northern Polar Circle, have the Light of the

7.
The Reason of the Days being longest at the Summer Solstice.

[D 2]

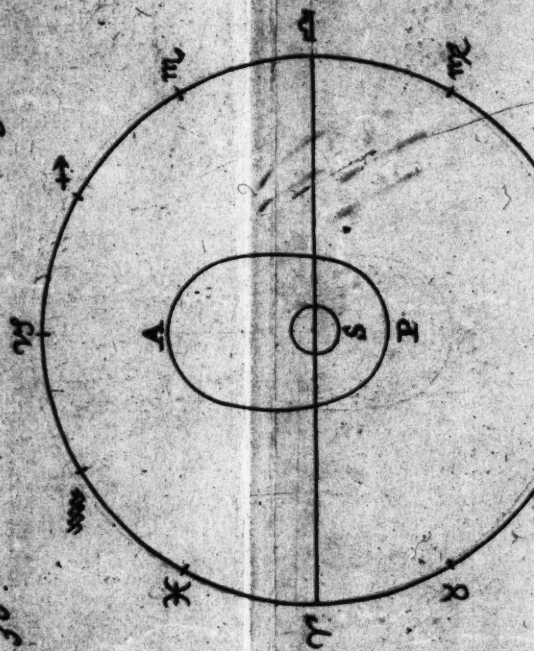
Sun;

Sun ; but the greater Portions of the Parallels, as lie between the *Equator* and southern *Polar Circle*, have in the Light of the *Sun* ; and the Portion of the Parallel, which is or is not enlightened, is so much the greater or lesser, as the Parallel is more or less distant from the *Equator*, the being exactly one Half of the *Equator* always enlightened, and the other not. And hence it is, that in the Position of the Earth in the first of *Capricorn*, when the *Sun* seems to be in the opposite, viz. first Degree of *Cancer*, the Days are longest in the northern Parts of the Earth, and the Nights shortest, and so it is Summer there. Whereas in the southern Parts of the Earth, the Days are then shortest, and the Nights longest, and so it is there Winter. And the longer Day is so much the longer, as the Place is more remote from the *Equator*. But to such as live on the Terrestrial *Equator* it self, Day and Night are now, and throughout the whole Year equal one to the other, for the Reason above-mentioned.

Astronomy Plate 6.

Place this facing Pag. 36.

Fig. 7.



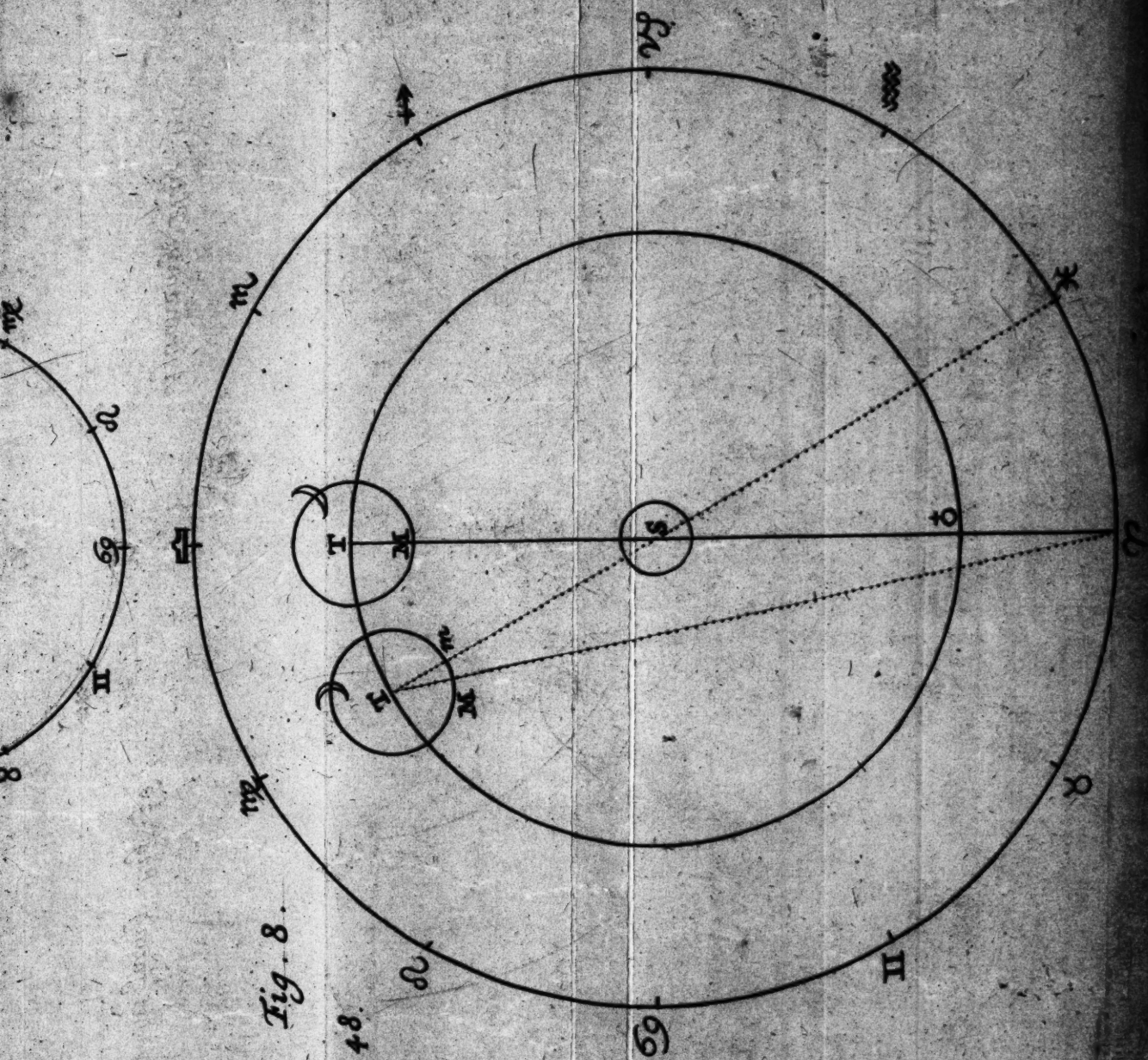


Fig. 8.

Fig. 48.

The Earth moving from w to r , the Sun will seem to move from s to $\equiv$, and so will appear in the Celestial Equator, and make Day and Night equal, as when the Earth was at the opposite Point $\equiv$, for the like Reasons. In like manner the Earth moving from r to s , the Sun will seem to move from $\equiv$ to w , where it is in its greatest Southern Declination. And consequently at this Time of the Year, the like Phenomena will happen to the Inhabitants of the southern Hemisphere of the Earth, as happened to those of the northern Hemisphere, when the Earth was in w ; and the like Phenomena will be in the northern Hemisphere, as were afore in the Southern.

8.
The Autumnal Equinox, and the Reason of the Days being shortest at the Winter Solstice, explained.

Having thus shewn, that the same Phenomena, as to the Length of Day and Night, and so as to the various seasons of the Year, will arise from the Annual Motion of the Earth round the Ecliptick, as from that of the Sun, at the four Cardinal Points of the Ecliptick, viz. the two Equinoctial, and the two Solstitial Points; it is obvious, that the same Phenomena will likewise happen at any the intermedi-

9.
The Solution of the like respective Phenomena at the intermediate Points of the Ecliptick, is easily to be inferred from what has been said.

ate Points of the *Ecliptick*, from the Motion of the one as well as of the other, as to the Increase and Decrease of Day and Night, and consequently as to the Difference of Seasons.

10.
Of the different Distance of the Sun from the Earth, its seeming different Magnitude, and different Rate of Motion.

As the *different Length* of Day and Night, and the different Seasons at different Times of the Year are *Phænomena*, which escape no one's Observation, and have been already accounted for; so there are other *Phænomena* of the Sun, which are not so easily to be observed, and therefore are taken Notice of only by the more curious in these Matters. Such is the *different Distance* of the Sun from the Earth at different Parts of the Year, as also its appearing of a *different Magnitude*, and its seeming to move at a *different Rate*. For as the Sun's Diameter appears lesser about the Middle of *June*, and greater about the Middle of *December*, so the Sun is more distant from us in our Summer than in our Winter; and also seems to move slower in the former, than in the latter; insomuch that it takes up about eight Days more in its seeming to pass from the Vernal to the *Autumnal Equinox*, than in its see-

ing to pass from the *Autumnal* to the *Vernal*; although in both Intervals of Time it seems to pass over but an equal Portion of the *Ecliptick*, namely, just Half. These *Phænomena* of the *Sun*, as they depend one on the other, so may be all solved by the Annual Motion of the Earth, in an *Elliptical Orbit*, round the *Sun* placed in one of the (||) Focus's of the *Ellipsis*, as is illustrated, *Fig. 7*, where the Circle represents the *Ecliptick*, the *Ellipsis* represents the *Orbit* of the Earth, S the *Sun* placed in one of the Focus's of the said *Ellipsis*. Now about the Middle of *June* the *Sun* appears to us in the Beginning of *Cancer*, and consequently the Earth is in the Beginning of *Capricorn*, and so at the Point A of its *Elliptical Orbit*, that is, at its (*) *Aphelium* or greatest Distance from the *Sun*; whence the

Sun

(||) In *Fig. 5*. the *Sun* is placed in the Center, not at one of the Focus's, only for more Convenience sake in drawing the Figure. It may be easily conceived to be at the Focus next to the Sign of Φ , where it ought to be strictly.

(*) What is here called the *Aphelium* and *Perihelium*, is by such, as follow the Hypothesis of the *Sun's* real

Sun appears then less to us. About the Middle of *December*, the *Sun* appears to us in the Beginning of *Capricorn*, and consequently the *Earth* is then in the Beginning of *Cancer*, that is, at the point *P* of its *Elliptical Orbit*, and so at its *Perihelium*, or least Distance from the *Sun*; which therefore appears to us then greater. Further, as the Line drawn from *r* to *e* through the Center of the *Sun* divides the *Ecliptick* into two Halves, so it unequally divides the *Orbit* of the *Earth*; the greater Segment whereof answers to the six Signs of the *Ecliptick*, which the *Earth* passes under between the Vernal and Autumnal *Equinox*; and the lesser Segment answers to the other six Signs of the

real Annual Motion, called the *Apogee* and *Perigee*, and these suppose the *Sun* to move Annually round the *Earth* in an *Eccentric* Circle, which comes much the same as an *Elliptical Orbit*. The *Aphelium* and *Perihelium* are not always in the same Points of the *Ecliptick*, but move a little and a little forward according to the Series of the Signs. The former is presently reckoned about the 7th Degree of *Capricorn*, and the latter about the 7th Degree of *Cancer*. These are both Words derived from the Greek Language, and therein of the Importance above specified.

Ecliptick

Ecliptick, which the Earth passes under between the Autumnal and Vernal *Equinox*. Whence it comes to pass, that the Earth taking up more Time to go along the greater Segment of its Orb, than the lesser, the *Sun* seems to take up more Time, and consequently to move more slowly, in passing along the six Signs of the *Ecliptick* between the Vernal and Autumnal *Equinox*, than it does in passing along the other six Signs of the *Ecliptick* between the Autumnal and Vernal *Equinox*.

As the Time of the Earth's Annual Motion from any Point of the *Ecliptick* to the same again, is computed 365 Days, 5 Hours, and 49 Minutes; so the Time of the Earth's Motion from the Vernal to the Autumnal *Equinox*, is computed 186 Days, besides some odd Hours and Minutes; and from the Autumnal *Equinox* to the Vernal, 178 Days, besides some odd Hours and Minutes. So that the Difference between these two Intervals of Time is (as afore has been observed) about eight Days.

II.

The Time of the Earth's Annual Motion, or of the Solar Year.

But

12.

The Sun,
why hotter
to us in
Summer,
though
farther
from us.

But there are two Difficulties, which are to be removed. One is in reference to what has been said concerning the *Sun's* being more distant from the Earth in Summer than in Winter. For since the *Sun* is the Fountain of Heat, as well as Light to the Earth, it may be asked, how it comes to pass, that the *Sun* is *hotter* to us in Summer than in Winter; if so be it be *farther* from us in the former than in the latter. Now this Difficulty will be removed by considering, that the *Sun* (or any other igneous Body) feels more or less hot to us, not only as it is nearer or further from us, but also as its Rays come more or less directly to us. Whence, though the *Sun* be farther from us in Summer than in Winter, yet because its Rays are much more nearly perpendicular to us in the former than in the latter, therefore it is hotter to us in the former than in the latter Season. That the Rays of the *Sun* fall more nearly perpendicular, or more directly upon us in the Summer than in Winter, is obvious to infer from *Fig. 6.* For when in Summer the Earth is in the Beginning of *♋*, and consequently

Sun appears to be in the Beginning of ϕ , the *Sun* is then in a perpendicular Line to T, or the Rays of the *Sun* then fall perpendicularly on the Terrestrial *Tropick* T C; and therefore, although the Earth be about that Time in its *Aphelium* or greatest Distance from the *Sun*, yet the *Sun* is then hottest to us in these Parts of the Earth north of the said *Tropick*. But as the Earth moves from the Beginning of ψ towards γ and ϕ , so the Perpendicular from the *Sun* to the Earth moves from T towards M; to which last the *Sun* is exactly perpendicular, when the Earth is in the first of ϕ , or at the Winter Solstice. Wherefore, although the Earth be about that Time in its *Perihelium* or least Distance from the *Sun*, yet the *Sun* is not then so hot to us, because its Rays fall most obliquely; as is evident by supposing a right Line drawn from the *Sun* to the point T in that Position of the Earth at ϕ .

The other Difficulty is in reference to the *Annual* Motion of the Earth round its *Orbit*. For such a Motion seems inconsistent with the Earth's retaining

13.

The
Change of
the Earth's
Place in
its Annual

Orbit, why
it makes
no sensible
Change as
to the
Earth's Si-
tuation in
respect of
the fixed
Stars:

retaining always the same Situation in Respect to the fixed Stars. But it is to be known, that the Circle of the Earth's Orbit is so very little in Respect of the Sphere of the fixed Stars, that the Earth's changing its Place in the said Orbit by its *Annual* Motion, makes no sensible Change of the Earth's Situation in Respect of the fixed Stars. In whatever Point of her *Annual Orbit* the Earth is, its *Ax* and *Equator* (being each every where Parallel to it self) will, if produced fall on the same fixed Stars as to our Sense, or so far forth as we can discern by our Sight; and consequently all the Rest of the fixed Stars (forasmuch as they retain the same Situation among themselves) will (†) retain the same Situation in Respect of the *Celestial Equator* and *Poles*; the *Celestial Equator* being always directed over the *Terrestrial*, and the *Celestial Poles* being always directly in right Line with the *Poles* of the Earth.

(†) Excepting the Change mentioned, Chap. Sect. 5.

An Eclipse
of the Sun,
improperly
so called.

These Difficulties being removed, the only *Phænomenon* which remains here to be taken Notice of, is that commonly called *the Eclipse of the Sun*, but which ought to be called *the Eclipse of the Earth*. For the Word *Eclipse* does in the *Greek* Tongue signify a *Deficiency*; and it is used in this Case to signify particularly that *Deficiency of Light*, which seems indeed to us to be in the *Sun*, but in reality is such only in Respect of the *Earth*. For the *Sun* is the Fountain of Light to this our Solar System; and consequently not receiving its Light by the Irradiation of any other Body upon it, but having its Light in it self, cannot suffer any such Defect of Light truly and really. Its Light may indeed be intercepted, or hindered from coming to us, by the Interposition of some opacous Body between Us and the *Sun*. But then it is the *Earth*, on which we are, not the *Sun*, that is deficient of Light, or in an *Eclipse*; and the opacous Body, whose Interposition between the Sun and Earth, causes the Earth to be thus in an eclipse, is the Moon. Wherefore the explanation of this *Phænomenon* depending

pending on the Motion of the Moon it will be requisite to speak first of that ; after which I shall in a distinct Chapter explain the Eclipses both of the Sun (as it is commonly called) and also of the Moon.

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C H A P. IV.

Of the Phenomena relating to the Moon.

THE Moon is a *secondary Planet*, forasmuch as she moves round the Earth primarily and immediately; and round the Sun only in a *secondary Manner*, viz. as she moves round the Earth, which moves round the Sun.

1.

The Moon,
a secondary Planet.

A *Period*, or Single Revolution of the Moon round the Earth from any Point of the *Zodiack* to the same, is called the Moon's (*) *Periodical Month*; and consists of 27 Days, 7 Hours, and 3 Quarters.

2.

A Periodical Month,
what.

The Time from one *Synod* or Conjunction of the Sun and Moon to another, is called the Moon's (*) *Synodical Month*, and consists of 29 Days, 12 $\frac{3}{4}$ Hours.

3.

A Synodical Month,
what.

(**) The Words *Period* and *Synod* are both of Greek extraction, the former denoting a going Round a thing, the latter a Meeting together of two or more things.

The

4.
The Syn-
nodical
Month,
why longer
than the
Periodi-
cal.

The Reason of the *Synodical* Month being so much longer than the *Periodical*, is illustrated *Fig. 8*, where the Circle S denotes the Sun, the Circle T & the Orbit of the Earth, T the Place of the Earth in the said Orbit, the Circle M > the Orbit of the Moon; M or m two several Places of the Moon in her Orbit; the outer most and greatest Circle, the *Zodiack*. Now let the Earth T be supposed in the first of *Libra*, and the Moon to be in her Orbit at M (in a right Line between the Earth and the Sun, and so) in *Conjunction* with the Sun in the first of *Aries*. The Moon moving thence Eastward, or according to the Series of the Signs, after 27 Days and an half appears to us again in the first of *Aries*, i. e. at the point M of her own Orbit, in the second Position of the Earth. For in the mean while the Earth has also moved almost a whole Sign Eastward, viz. almost to the End of *Libra*. And hence the Moon M, though come again to the first of *Aries*, is almost a whole Sign Westward of the Sun. This is represented by the two prick'd Lines whereof that from m (in the second Position

tion of the Earth) to γ represents
the Moon appears then to us in
First of *Aries*, while the other
from m through S to the End
of γ represents how the Sun
appears at the same Time to be al-
most out of *Aries*, and so almost a
whole Sign Eastward of the Moon.
Therefore the Moon must still move
much further, viz. from M to m
her own *Orbit*, before she will be
Conjunction again with the Sun.
going of which to overtake the
is taken up the Time, whereby
Synodical Month exceeds the *Pe-
rical*, viz. 2 Days, 5 Hours.

is the *Synodical* Month, which is
principally made Use of in Computa-
tion of Time. Forasmuch as the se-
veral Parts of this Month are sensibly
be distinguished by the several
Phases or Appearances of the Moon,
respectively belonging thereunto.

The several Phases of the Moon
are accounted for thus. The Moon
is conceived to be an opacous Body,
a Body which receives its Light
from the Sun. It is also spherical,
consequently has always one Half
enlightened, namely, that Hemi-
sphere

3.

The *Sy-
nodical*
Month of
chief Re-
gard.

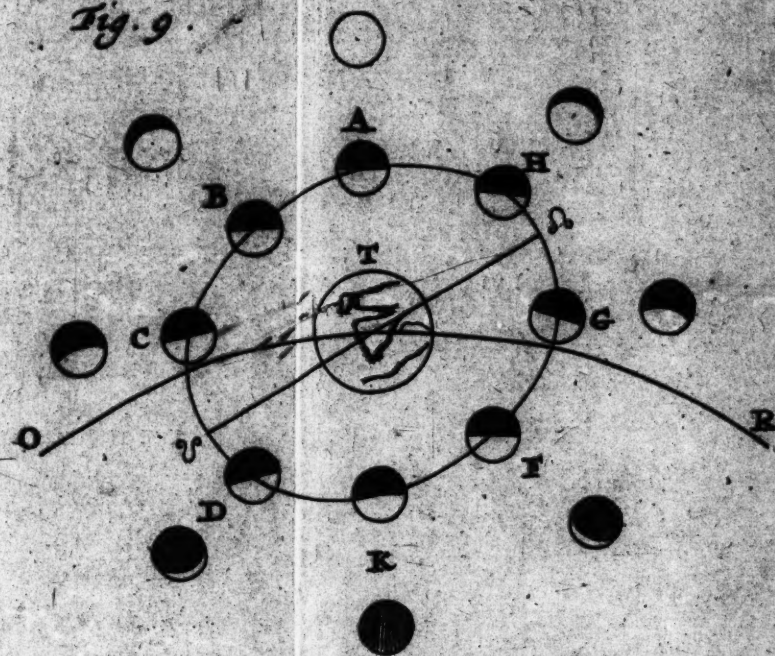
6.

The *seve-
ral* Phases
of the Moon
accounted
for.

[E]

sphere which is towards the
 Now from this Hemisphere
 seen, sometimes more sometimes
 of it, by us, arise the several
 of the Moon, for the better un-
 standing whereof it is to be
 observed, that although the Moon
 a spherical Body, yet the enlight-
 Portion of it, which is seen
 appears by Reason of its Distance
 if the Moon had a plain Surface
 which is illustrated, *Fig. 9.* *W*
 denotes the Sun, *T* the Earth,
 Part of the Earth's Orbit, *AC*
 Orbit of the Moon, on the
 more remarkable Points whereof
A, B, C, D, K, F, G, H, is
 sented the Moon with its enlight-
 and darkened Hemisphere;
 each Point so much of the enlight-
 ed Hemisphere, as is within the
 cle *ACKG*, is seen by us,
 appears to us, not as it is there
 sented, (*i. e.* not as a Portion
 Hemisphere,) but as a Portion
 some plain circular Surface, as
 presented by the several little
 Draughts respectively adjoining.
 being premised, 'tis evident from
 said Figure the 9th, that the

Fig. 9.



of the Moon.

51

being at A, all its enlightened Hemisphere is towards the Earth, and seen by Us, whence the Moon appears to us with a full Orb, (as is with a plain circular Surface all enlightened,) which Phasis or Appearance is there called the *Full Moon*. The Moon being moved to B, it is evident, that only some Part of its enlightened Hemisphere will be towards the Earth, and so seen by us, whence the Moon will appear like a (†) plain circular Surface, but not fully enlightened, but somewhat defective of light on that Side which is from the Sun, and consequently will appear gibbous. The Moon being moved to C, just Half of its enlightened Hemisphere will be towards the Earth, and seen by Us: Hence the Moon will appear then to us as half Orb, or with a semicircular Surface. The Moon being moved to D, a very little Portion of its enlightened Hemisphere will be seen by Us, and this will appear horned, the Horns bending from the Sun, and

(†) Hence the Face of the Moon is called *Discus*, resembling a flat round Dish.

[E 2]

so

so (II) westward. The Moon being come to K, none of its enlighten'd Hemisphere will be towards the Earth, and so the Moon will not be seen by us, and then it is said to be *New Moon*; because the Moon will a little after appear anew in F, and then again horned, the Horns now likewise bending from the Sun, and (II) eastward. After which the Moon will appear at G with an half Gibbous again, (as at C;) and at H gibbous again, (as at B;) and so will proceed to A, where it will be again Full Moon. And so the Moon will have undergone her several Phases; which though they somewhat vary every Day, nay, every Hour; yet are usually taken Notice of, and distinguished only in the fore-mentioned Points.

7.

The remarkable Phases of the Moon, five.

Hence the remarkable Phases of the Moon are five; whereof the principal are the *New* and the *Full* Moon. The three other, *viz.* *Gibbous*, *Half*, and *Horned* Moon.

(III) Hence the memorial Verse,
Dextra cavum Veteris complebit, Laeva Recens

occur both between the New and Full Moon, and also between the Full and New Moon; only in a different Order. Between the New (which is also called the *Change*) and the Full, the Moon is first horned, then halved, and lastly gibbous; whereas between the Full and Change, she is first gibbous, then Halved, and lastly horned.

When the Moon is thus Horned, a little before and after the New Moon, (*viz.* when the Moon is at the Points D and F,) besides its bright horns, the Moon has a faint Light, whereby all the Rest of its Discus is hardly discernable. This faint Light has been thought by some to be the Moon's Native proper Light; but it is now generally supposed by the learned in Astronomy to be no other than a Reflexion of the Sun's Rays upon the Moon, the Earth's Position being such at this Time, as very well admits to such a Reflexion, as may be seen, *Fig. 9.* And this Supposition is rendered still more probable, because as soon as the Moon is moved beyond the Limits of such a Reflexion

[E 3] from

8.
The faint Light which is seen in the whole Discus of the Moon, a little before and after its Change; whence supposed to arise.

from the Earth, the fore-mentioned faint Light ceases.

9.
of the
Moons A-
pogee and
Perigee,
&c.

What has been afore observed of the Sun, is also observed by the Moon; namely, that one Part of her Orbit she appears lesser, and (*ceteris paribus*) flower; the opposite Part bigger and swift. Which Phenomena may be solved in the like manner, as are the Phenomena of the Sun; viz. by the Moon's Motion in an elliptical Orbit having one of its Focus's in the Center of the Earth. Accordingly may be illustrated by Fig. 7, supposing the Ellipsis A P (which there represents the Orbit of the Earth) to represent the Orbit of the Moon, the Circle S (which there represents the Sun) to represent the Earth. then A will represent the Moon at Apogee or greatest Distance from the Earth, when she will appear lesser, and P her Perigee or least Distance, when consequently she will appear greater. And because she is longer passing the greater Segment of her Orbit between her Apogee and the Center of the Earth, than the lesser

ment between the said Focus and her
 erigee ; therefore she will appear to
 move slower, while she passes along
 that Half of the *Zodiack*, which an-
 swers to the greater Segment of her
 orbit ; and swifter, while she passes
 the other Half of the *Zodiack*, an-
 swering to the lesser Segment of her
 orbit.

Among the *Phænomena* of the Moon
 more obvious to our Sense, there re-
 mains only the Eclipse of the Moon
 to be spoken of, which shall be ex-
 plained in the following Chapter.

[E 4]

CHAP.

C H A P. V.

*Of the Eclipses of the Sun
Moon.*

I.
An Eclipse
of the Sun
and Moon,
what.

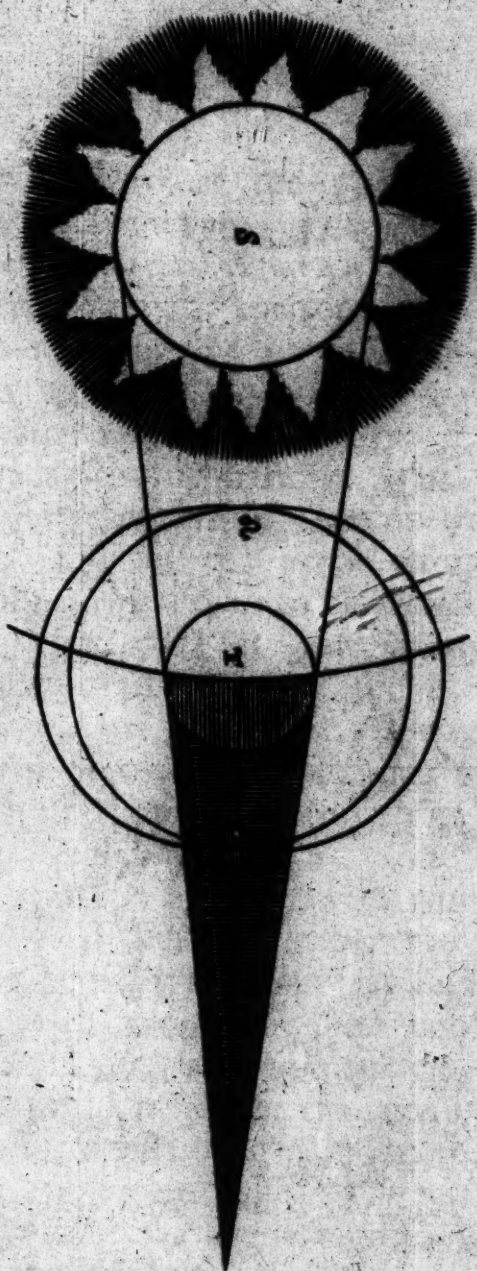
THE Eclipses of the Sun and Moon are here spoken of together, because as they arise from the same Causes, so are they to be explained much after the same Manner. It is to be remembred, that it has been before (*) observed, that what is commonly called the Eclipse of the Sun is in reality the Eclipse of the Earth. Wherefore, the Earth and Moon being both opacous Bodies, which receive Light from the Sun, an Eclipse of the Earth (commonly called Eclipse of the Sun) is no other than a Deficiency of Light on the Earth, by the Moon's coming between the Earth and the Sun, so as to hinder the Light of the Sun from falling on the Earth, just as an Eclipse of the Moon

(*) Chap. 3. Sect. 13.



Place this facing Fig. 57.

Fig. 10.



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Deficiency of Light in the Moon, by the Earth's coming between the Moon and Sun, so as to hinder the Rays of the Sun from falling on the Moon.

Hence it is evident from Fig. 9, that all Eclipses of the Earth happen at the Change of the Moon, because then only it is that the Moon comes between the Earth and the Sun; and all Eclipses of the Moon happen at the Full of the Moon, because then only it is that the Earth can come between the Moon and the Sun.

2.
Eclipses of
the Sun
and Moon,
when hap-
pen.

It is to be shewn further, for what Reasons there is not an Eclipse of the Earth at every Change, but only at some certain Changes of the Moon; nor an Eclipse of the Moon at every Full, but only at some certain Full Moons. It is then to be known, that the Orbit of the Moon crosses the Ecliptick, so as to make an Angle of 5 Degrees Inclination. The Points where the Moon crosses the Ecliptick, are called the Nodes of the Moon, and are denoted, Fig. 10, by these Characters α and ω ; the former of which is called the Dragon's Head, the latter the Dragon's Tail. The Moon crosses the Ecliptick at the Dragon's Head, when

3.
Why not
at every
Change or
Full of the
Moon, but
only at
some cer-
tain Ones.

when she is entering on that Part of her Orbit, which inclines northward from the *Ecliptick*; and she crosses the Dragon's Tail, when she is entering on that Part of her Orbit, which inclines southward from the *Ecliptick*. Now the Nodes being the only two Points, where the Moon crosses the *Ecliptick*, hence there can be no Eclipse of the Earth, but when the Moon happens to Change in or near one of the Nodes; because in this Case only, the Moon at her Change comes so between the Earth and the Sun, as to intercept the Rays of the Sun, and keep them from the Earth. And in like manner, there can be no Eclipse of the Moon, but when the Moon happens to be at Full, in or near one of the Nodes; because in this Case only, the Earth comes between the Moon and the Sun, to intercept and hinder the Rays of the Sun from falling on the Moon.

4.
The Shadow, in Eclipses of the Sun and Moon, of what Figure.

In an Eclipse of the Earth, the Moon by intercepting the Rays of the Sun, casts a Shadow on the Earth. And in an Eclipse of the Moon, the Earth by intercepting the Rays of the Sun, casts a Shadow on the Moon.

The

(†)
(II)

These Shadows are of a (†) conical Figure, growing narrower and narrower, the further they go from the Earth and Moon, till at Length they end in a Point, and so cease. Were these Shadows, either of a (||) cylindrical Figure, i. e. of an equal Thickness all along; or of a (||) conical Figure, but inverted the other Way, i. e. did they grow thicker and thicker, the further they are extended, then they would be extended in *infinitum*. But now 'tis certain, that the Shade of the Earth does not extend to the *Orbit* of the primary Planet *Mars*; forasmuch as when the Earth is directly between the Sun and *Mars*, the latter is not eclipsed, as it must necessarily be, did the Shade of the Earth reach to the *Orbit* of *Mars*.

It being thus demonstrable, that the Shadow of the Earth ends in a Point, before it comes to the *Orbit* of *Mars*; hence it is also demonstrable, that the Sun is bigger than the Earth; forasmuch as an opacous Body can't

5.
The Sun
how de-
monstrated
to be big-
ger than
the Earth,
and the
Earth than
the Moon,

(†) As in Fig. 13.

(||) This is evident from Fig. 11. and 12.

cast

cast such a conical Shade, but when it is lesser than the lucid Body, which Rays it intercepts. For if the opacous Body be equal to the lucid Body, then the Shadow will be of equal Thickness all along. And if the opacous Body be greater than the lucid Body, then the Shadow will indeed be of a conical Figure, but in an inverted Manner, that is, so that the conical Shade will grow wider and wider, as it goes further and further. And as the Sun may thus demonstrated to be bigger than the Earth, so the Earth may be demonstrated to be bigger than the Moon; forasmuch as the Moon can be totally Eclipsed. For this could not be, was not the Cone of the Earth's Shadow, even in that Part of it which the Moon passes through in a total Eclipse, bigger than the Moon though it be lesser than the Earth itself: what is here said is illustrated in Fig. 11. 12, 13.

6. The Shadows of the Earth and Moon being thus of a conical Figure, it is obvious that an Eclipse either of the Earth or of the Moon will be (*ceteris paribus*) greater long

*The Great-
ness of an
Eclipse de-
pends in
one Respect
on the*

Place this facing Bag. 60.

Fig. 11



Fig. 12

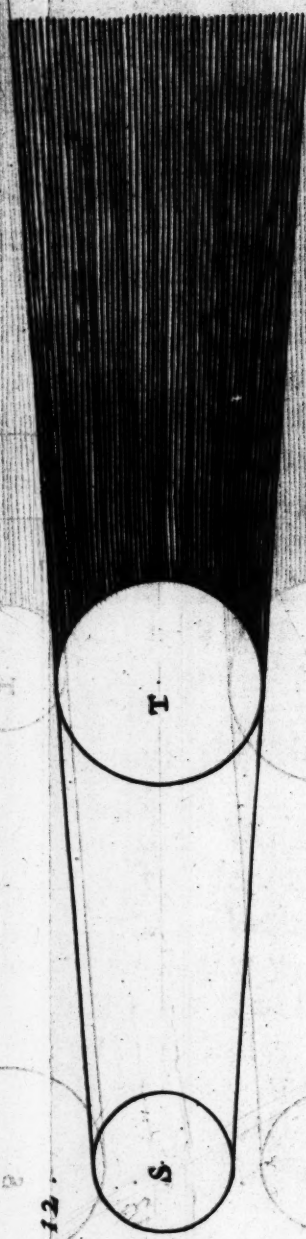


Fig. 13

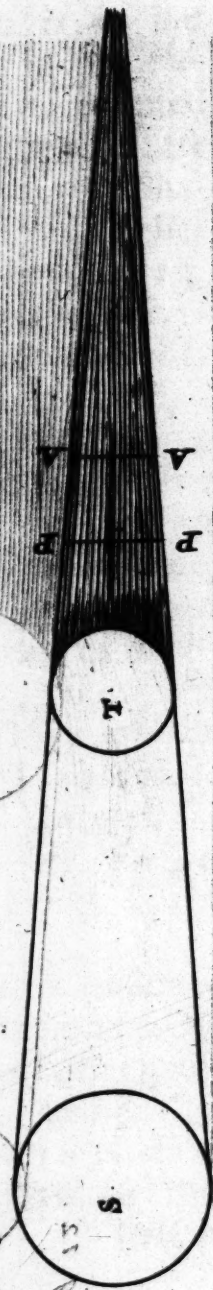


Fig. 14.

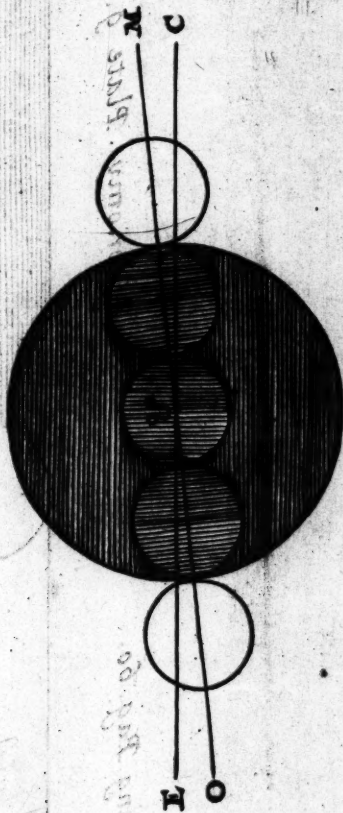


Fig. 15.

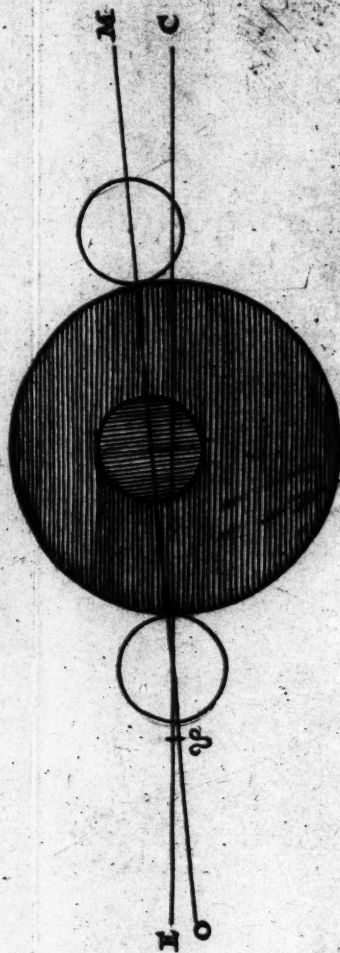
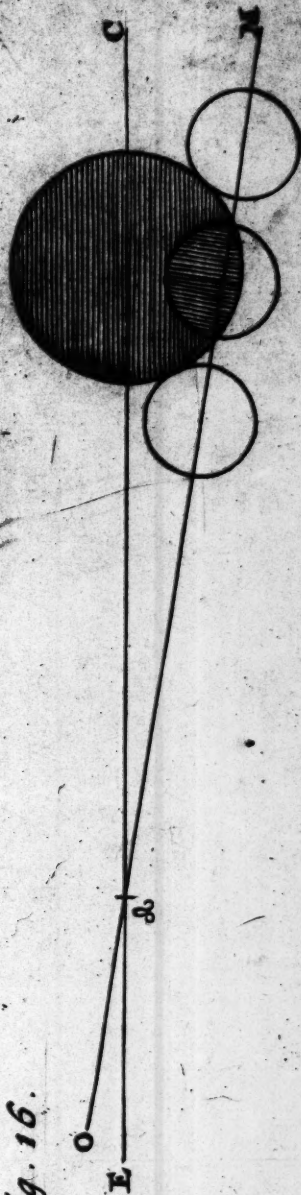


Fig. 16.



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longer, when the Moon is in her *Perigee*, than when she is in her *Apogee*. For the Moon, if she be eclipsed in her *Perigee*, meets with a thicker Part of the Line of the Earth's Shadow, than if she be Eclipsed in her *Apogee*; as is obvious from *Fig. 13*, where the Line PP denotes the Moon's Passage through the Shadow in her *Perigee*, and the Line AA in her *Apogee*. And in like manner, if the Earth be eclipsed when the Moon is in her *Perigee*, it meets with a thicker Part of the Cone of the Moon's Shade, than it does if it be eclipsed when the Moon is in her *Apogee*; as is obvious also from *Fig. 13*, taking the Circle T to denote the Body of the Moon; and the Line PP to denote the Passage of the Earth through the Shade of the Moon in her *Perigee*, and AA to denote the like in the *Apogee* of the Moon.

But the Variety, that is observed in Respect to the Greatness and Duration of Eclipses, does principally arise from the Moon's being then more or less distant from a Node or the *Ecliptick*. Which shall be illustrated,

Moon's being in her Apogee or Perigee.

7.
But principally on the Moon's Distance from her Nodes.

strated, first in reference to the Moon then in reference to the Earth.

8. An Eclipse of the Moon, considered as to its Greatness, is either Total when the whole Moon is eclipsed or Partial, when only a Part of it is eclipsed.

9. As to Duration, every total Eclipse holds longer than any partial One. And as some partial Eclipses are of longer Duration than others Partial, so some total Eclipses are longer Duration than others Total. Such total Eclipses, as are of the longest Duration, happen when the Moon is in a Node, and are called central Eclipses, because, as the Moon passes through that Section of the Cone of the Earth's Shadow, which meets with the Orbit of the Moon, the Center of the Moon passes exactly through the Center of the said Section or Shadow.

10. This is illustrated, Fig. 14, where the shaded Circle represents the Section afore-mentioned of the Earth's Shadow; OM the Orbit of the Moon EC the Ecliptick. 'Tis evident, that the Moon in this Case crossing a Diameter of the shaded Circle, makes

long

longest Stay she can make in the Shadow of the Earth; and this Stay is computed about four Hours long. Whereof the Moon takes up one Hour from her Beginning to enter into the shadow, till she is quite immersed therein; two Hours more she continues quite immersed; passing on through the shadow; and the fourth hour is taken up, from her first Beginning to come out of the shadow; till she is got quite free of it. Whence by the way it appears, that the Width of the Shade is equal to about four Diameters of the Moon.

In Fig. 13, is represented a Total, but not central Eclipse; which happens when the Moon meets with the shadow of the Earth, though not at a Node, yet at a small Distance from it. And as it is obvious from the same Figure, that every total, but not central Eclipse must be of shorter duration than a central, so it is also obvious, that one total, but not central Eclipse will be longer than another, in Proportion to the Moon's greater or less Distance from a Node at that Time.

II.
A Total,
but Not-
central E-
clipse of
the Moon.

In

12.
A partial
Eclipse of
the Moon.

In Fig. 16. is represented a partial Eclipse. And it is evident from the same Figure, that as any total Eclipse must be of longer Continuance than any partial; so one partial Eclipse of longer Continuance than another according as the Moon is then more or less distant from a Node. It is also obvious, that the longer a partial Eclipse is, so much greater is *i. e.* so much greater Part of the Moon is darkened or passes through the Shadow of the Earth. Hence it is usual to conceive the Moon's Diameter, as divided into twelve Parts, called *Digits*; by which the Greatest partial Eclipses are measured and distinguished; they being said to be so many Digits, as there are twelve Parts covered by the Shadow of the Earth, when the Eclipse is greatest.

13.
Of the Pen-
umbra in
Eclipses of
the Moon.

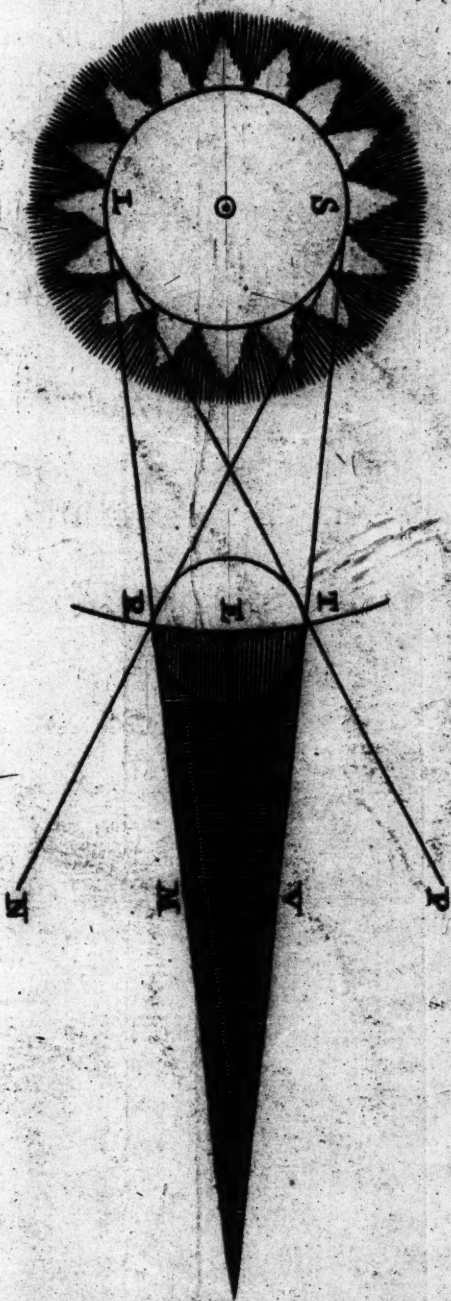
In all these Eclipses of the Moon she enters the western Side of the Shadow with her eastern Side; so it is her western Side which quits the eastern Side of the Shadow when the Eclipse ceases. But now the eastern Limb or Side of the Moon draws towards the Shadow; be-



Astronomy Plate 10.

Place this facing Fig. 65.

Fig. 17.



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enters the thick Shadow it self, and quite darkened, it grows more and more dim, as it comes nearer and nearer to the Shadow. Which Dimness arises from a Penumbra or Duskiness, which always attends such Shadows, and encompasses them all round. Thus Fig. 17, TUMR represents the Shadow, (where comes any Part of the Sun's Light,) which is encompassed all round with the Penumbra UTPMRN, where by some Part of the Sun's Light is intercepted by the Earth. And this Penumbra is more dim towards TU and MR the edges of the perfect Shadow, because the Rays of a lesser Portion of the Sun, and so fewer Rays reach thither; and less dim towards TR and RN, where more Rays fall; and beyond which Limit, the Rays of the Sun have a free Passage.

In some Eclipses the Moon quite appears in the perfect Shadow. At other Times she appears even in the Part of the perfect Shadow, of a reddish Colour like a burnt Brick. This reddish Colour is supposed to arise from the Rays of the Sun, ei-

[F]

ther

14.

The Moon, why appear of a reddish Colour in total Eclipses.

ther refracted in the Atmosphere about the Earth, or reflected to the Moon by Particles flying without the Shadow of the Earth; or else to arise from the Illumination of the Stars, or all these Causes together.

15.
How many
Eclipses of
the Moon
usually
happen in
a Year.

There happen most Years two Eclipses of the Moon at least. For there being two Nodes, wherein the Moon crosses the *Ecliptick*, and which move contrary to the Series of the Signs, and the Earth going round the *Ecliptick* every Year the other Way, or according to the Series of the Signs; hence it is obvious, that the Earth must meet the Moon's Nodes every Year. If therefore it happens then to be Full Moon, there must be a central Eclipse. If it be not Full Moon, but more than ten Days (and more than fifteen it cannot be) either before or after a Full Moon, yet so great is the Inclination of the Moon's Orbit to the *Ecliptick*, and so great is the Thickness of the Corner of the Earth's Shadow, that the Moon will scarce miss going through some Part of the Shadow; and consequently there will be at least a partial Eclipse. But if the Earth happens

meet a Node of the Moon on the very Day of a New Moon, or one or two Days before or after, (which happens but seldom) in this Case the Moon will be far enough to avoid the Shadow of the Earth, both in the foregoing and also following Full Moon; and so there will be no Eclipse of the Moon that half Year. and this may suffice in Relation to the Eclipses of the Moon.

Proceed we now to the Eclipses of the Earth, which are commonly called Eclipses of the Sun, forasmuch as the Moon, which more or less covers the Sun, being not seen by us, the deficiency of Light appears to our sight as in the Sun it self. Whence an Eclipse of the Sun is distinguished into a *total* Eclipse, wherein the Moon covers the whole Body of the Sun from us; and a *partial* Eclipse, wherein the Moon covers only a Part of the Sun.

16.
An Eclipse
of the Sun
Total or
Partial.

But it is to be well observed, that though an Eclipse of the Sun be in reality an Eclipse of the Earth; yet it is called a *total Eclipse of the Sun*, is not to be conceived as in reality a *total Eclipse of the Earth*; or

17.
Of a total
Eclipse of
the Sun.

that the whole upper and opposite Hemisphere of the Earth is then deprived of the Sun's Light, as in a total Eclipse of the Moon is the whole opposite Hemisphere of the Moon. The Reason of which Difference is this. The Earth being bigger than the Moon, the Cone of its Shadow is big enough to involve the whole opposite Hemisphere of the Moon in Darkness. Whereas the Moon being less than the Earth, the Cone of its Shadow will involve at once only a small Tract (CD in Fig. 8,) of the opposite Hemisphere of the Earth, as to hide the whole Sun from the Inhabitants thereof; and consequently there will appear only to them a total Eclipse of the Sun, whilst to the Inhabitants of the adjoining Tracts BC, and DE, the Sun will appear to be but partially Eclipsed: and beyond these on each Side, there will be no Eclipse at all of the Sun, as is evident from the same Fig. 18.

18.
The Sun
continues
totally E-
clipsed, but
a very short
While.

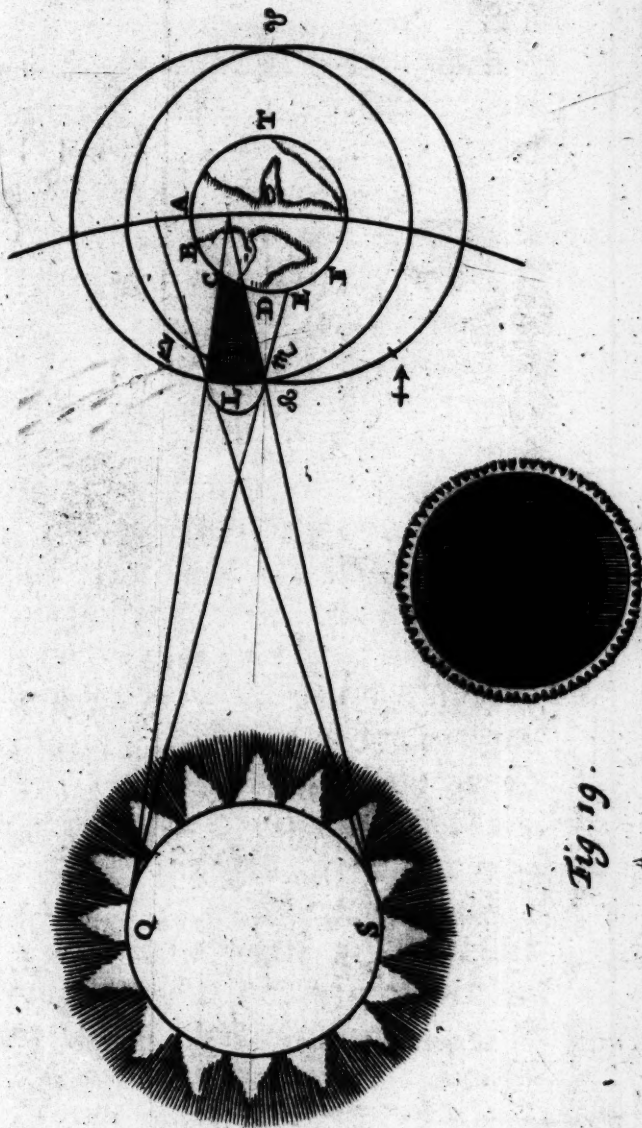
The Moon moving from West to East, that is, from α through γ 4, hence her eastern Limb appears to us first to cover the western Limb of the Sun. And when there

Astronomy Plate II.

Place this facing Pag. 68.

Place this facing Pag. 68.

Fig. 18.



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total Eclipse of the Sun, for the Time that the Moon covers all the Sun from us, it is so dark, as that sometimes the stars have appeared, and there has been need of Candle-light. But then this Darknes lasts but a very little While; for no sooner is the (*) Discus or Face of the Sun quite covered by the Moon, but almost presently some Part of the said Discus begins to be uncovered again, and a very little Part of it being so uncovered gives a considerable Light.

It happens sometimes, that a central Eclipse of the Sun is not a total Eclipse; but about the Limb or Edge of the Moon, which looks like a black dark Spot, may be seen the Limb of the Sun, which appears like a Circle of Light, as in *Fig. 19.* This is occasioned by the Shadow of the Moon being too short to reach quite to the Earth; and this Shortness of the Moon's Shadow may be occasioned, either by the Moon being in her *Apogee*, or else by the Rays of

19.
A central
Eclipse of
the Sun
may be not
a Total.

(*) The Sun's Face is called its *Discus*, for the like reason, as the Moon's Face is so called, taken Notice Chap. 4. Sect. 6.

the Sun, which pass by the Edge of the Moon, being bent by Inflection, and so shortening the Shade of the Moon.

20.
Of the
Number of
Eclipses of
the Sun in
a Year.

The greatest Eclipse of the Sun (wherein the Shadow of the Moon passes along the Middle of the Earth) is, when the Moon happens to be in a Node at the Moment of her Change. If she be not far from a Node, the Shadow of the Moon, or at least some Part of the Penumbra will fall on some Tract of the Earth, (as being large enough,) and will there make a Total, or at least partial Eclipse. And in this Respect there are more Eclipses of the Sun, than of the Moon. But in Respect of any one given Place of the Earth, there are much fewer visible Eclipses of the Sun than of the Moon, for the Shade of the Moon is lesser than the Shade of the Earth, and consequently the former will not so often involve any given Place of the Earth, as the latter will some Part of the Moon.

21.
The Ecliptick, why
so called.

It remains now only to observe that the *Ecliptick* is so called, because all the fore-mentioned Eclipses happen, only when the Moon is in

near a Node, *i. e.* in or near the Plane of the *Ecliptick*. And as all Eclipses of the Sun and Moon happen in the *Ecliptick*, so likewise do the Eclipses of the other Planets, of which we come now to speak.

[F 4] 102 CHAPTER.

Order may be seen. Fix a
Man. This will their top
these are three. Between
the Sun and their own Orbit
have the Orbit of the Earth
and Mercury; the latter are

of the Estates; yet their
Plans of their Obedience
your Plans agreed in this
Although both inferior and

C H A P. VI

Of the Phænomena of the primary Planets, of Saturn, Jupiter, Mars, Venus, and Mercury ; as also of the secondary Planets, or the Satellites of Saturn and Jupiter.

1. *The primary Planets distinguished into Superiour and Inferiour, with Respect to the Earth.* **A**S there are five primary Planets besides the Earth, so they are distinguished, by Reason of their Situation with Respect to the Earth, into *Inferiour* and *Superiour*. The former are such as move between the Earth and Sun, and are two, *Venus* and *Mercury* ; the latter are such as have the Orbit of the Earth between the Sun and their own Orbit, these are three, *Saturn*, *Jupiter*, and *Mars*. This with their respective Order may be seen, *Fig. 1.*

2. *Hence arises some Difference* Although both inferiour and superiour Planets agree in this, that the Planes of their Orbits cross the Plane of the *Ecliptick* ; yet their di-

Place this figure Fig. 73.

Fig. 20.

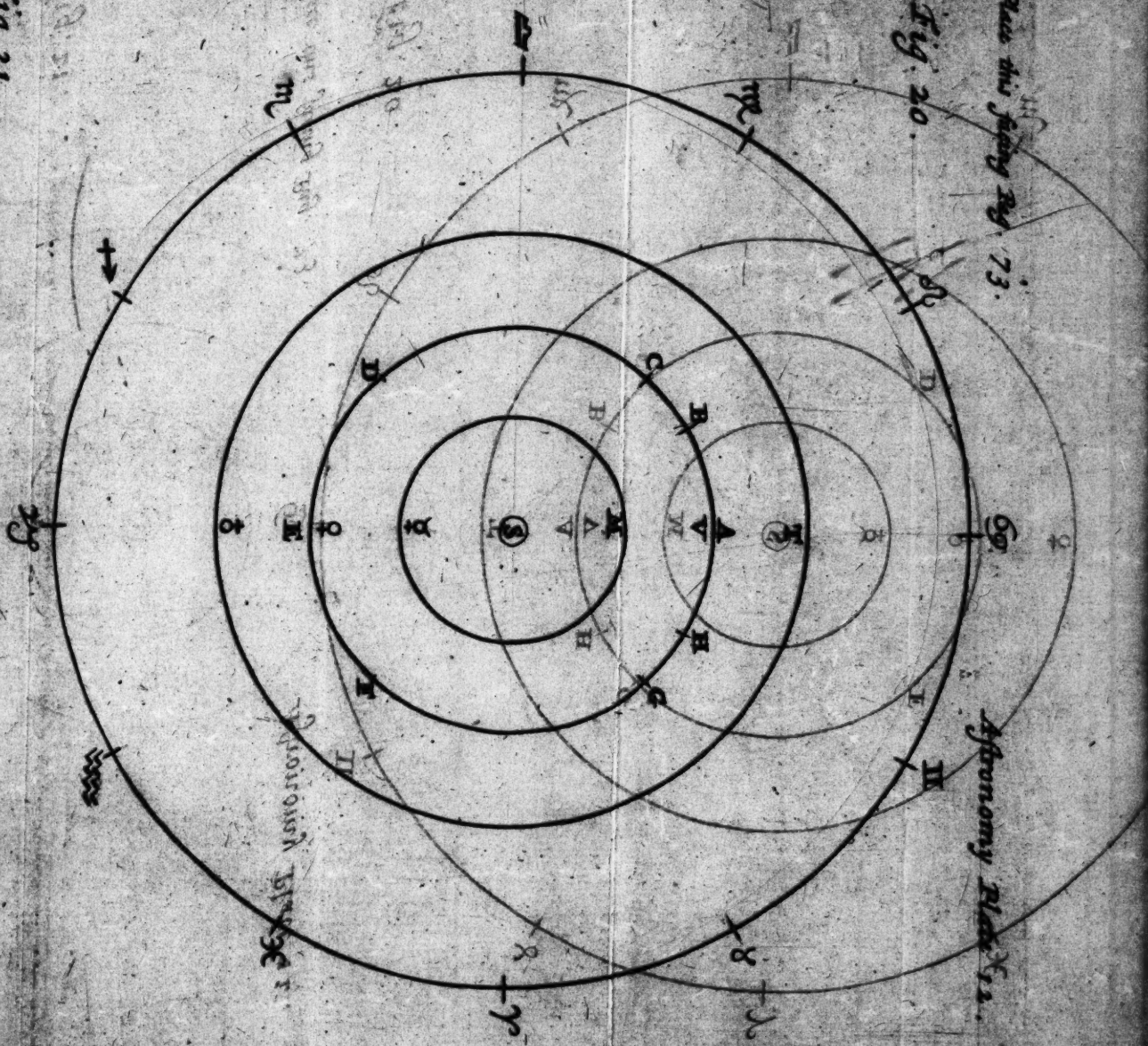


Fig. 21.

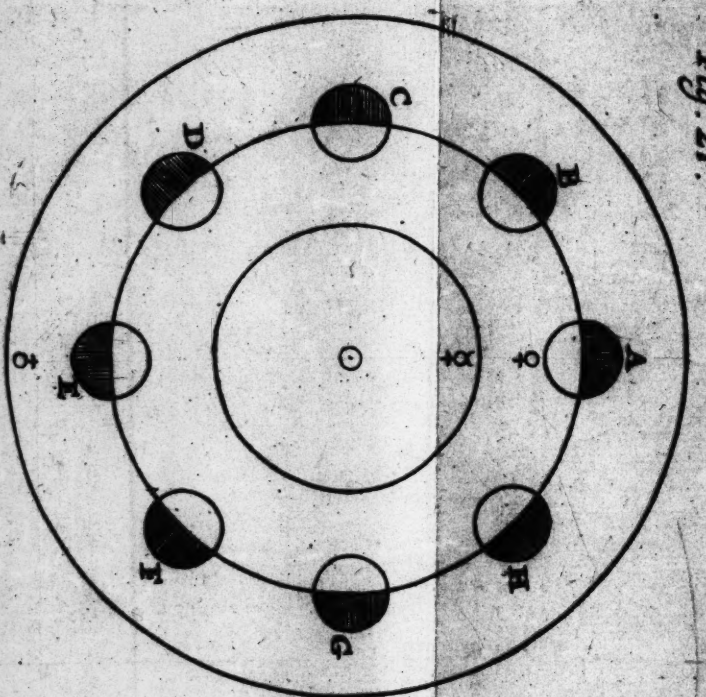
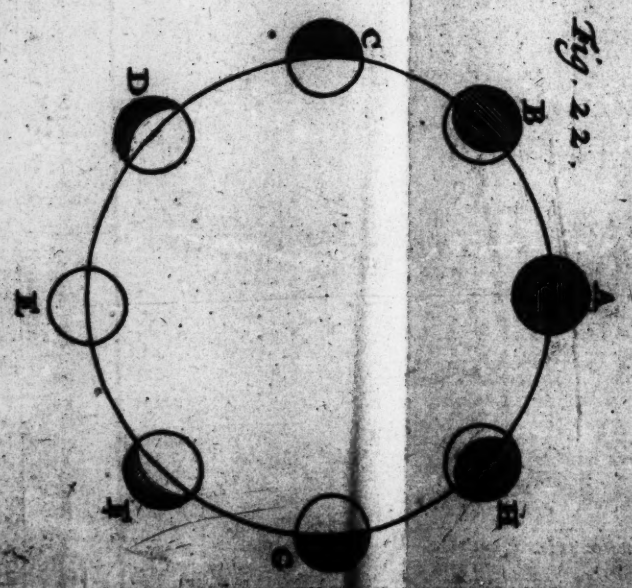


Fig. 22.



situation with Respect to the Earth as to their
occasions some Difference in the Phænomena.
Phænomena respectively belonging to them.

I shall begin with the inferiour 3.
Planets, whose Orbits together with The inferi-
the Orbit of the Earth and *Ecliptick* our Planet
are represented, *Fig. 20*, namely, *Venus*,
A represents the Orbit of *Mercury*, why it ap-
B of *Venus*, T the Earth in its Or- pears some-
bit, T 3, the outermost Circle, the times to
Ecliptick; the little Circle S in the move Di-
center, the Sun. Now *Venus* moving rectly,
in a lesser Orbit than the Earth, but sometimes
the same Way, viz. from West to Back-
East; it is evident, that when *Venus* ward, and
in D E T the more remote Part of sometimes
her Orbit from the Earth T, she will to stand
appear to us in T to move according still.
to the Series of the Signs, (viz. from
to *v*, &c.) and so to move di-
rectly forward. When *Venus* is come
to G, from thence to H, she will still
appear to move directly forward, but
slower than before; forasmuch as she
now moves as it were in a straight
line towards T the Earth. As she
passes beyond H through A to B,
moving quicker than the Earth, she
will pass between the Earth and the
Sun,

Sun, and will seem to us on the Earth to move contrary to the Series of the Signs, (*viz.* from ν to γ) and so to have a *retrograde Motion* or to move backward. Between the direct and retrograde Motion, *viz.* about H, she will appear *stationary* i. e. to stand still; forasmuch as the right Lines then joining the Earth and *Venus* will for some Time continue parallel. And in like manner between her retrograde and direct Motion, *viz.* about E, she will appear a second Time to stand still. From what has been said it is obvious, that *Venus* when she is retrograde, as at A, is nearer the Earth and therefore seems bigger; and on the other hand when she is direct, at E, she is more remote from the Earth, and so (*cæteris paribus*) seems lesser.

4.
The several Phases
of Venus.

The several Phases of *Venus*, according to her different Position with Respect to the Earth, are represented as they are in themselves, Fig. Whence it is evident, that when *Venus* is at A, that is, most retrograde and nearest to the Earth, she does not appear to us, her dark Face

of Venus and Mercury.

75

g towards us. And if she then happens to be in or near enough to a Node, she will pass directly between the Earth and Sun, and so seem as a Spot in the Sun. Otherwise, if she be far enough from a Node, she will go on one side of the Sun, either northward or southward. At B she will appear horned, at C with an half Orb, at D gibbous, and at E (where she moves most directly, and is most remote from the Earth) with a full Orb; unless she be then in or near enough to a Node, in which Cases she will be hid from us by the Sun. After her Full, *Venus* undergoes the same Phases as afore, only in an inverted order, till she comes to her Change again. As *Fig. 21*, represents the several Phases of *Venus*, as they are in themselves; so *Fig. 22*, represents them, as they appear to us on the Earth; the correspondent Phases being denoted in both Figures by the same Letters, A, B, C, &c.

Lastly, *Venus* moving round the Sun at a lesser Distance than the Earth is, hence to us she appears as always accompanying the Sun; her nearest Elongation or Distance from the

5.
Why Venus
appears
always ac-
company-
ing the
Sun; and

why called
Phospho-
rus, and
Hesperus,
&c.

the Sun being about 45 Degrees, Sign and Half. When she appears before the Sun in the Morning, so does as it were usher in Day: she is then called *Phosphorus* or *Lifer*, or the *Morning Star*; when she appears after the Sun at Evening, then she is called *Hesperus* or *Vesper*, or the *Evening Star*.

6.
Of the
Phenome-
na of Mer-
cury.

What has been said and illustrated concerning *Venus*, is also to be understood in reference to the like Phenomena of *Mercury*; only it must be considered, that the Orbit of *Mercury* being lesser than that of *Venus*, he never appears at such a distance from the Sun, being never more than one whole Sign distant from it, and very seldom to be seen. In the same manner, *Mercury* going round its Orbit in shorter Time than *Venus* does her Orbit; hence the direct Motions, Stations, and Retrogradations of *Mercury* will occur oftener, than those of *Venus*. And so much may be said for the two inferiour primary Planets.

7.
The A-
greement
between

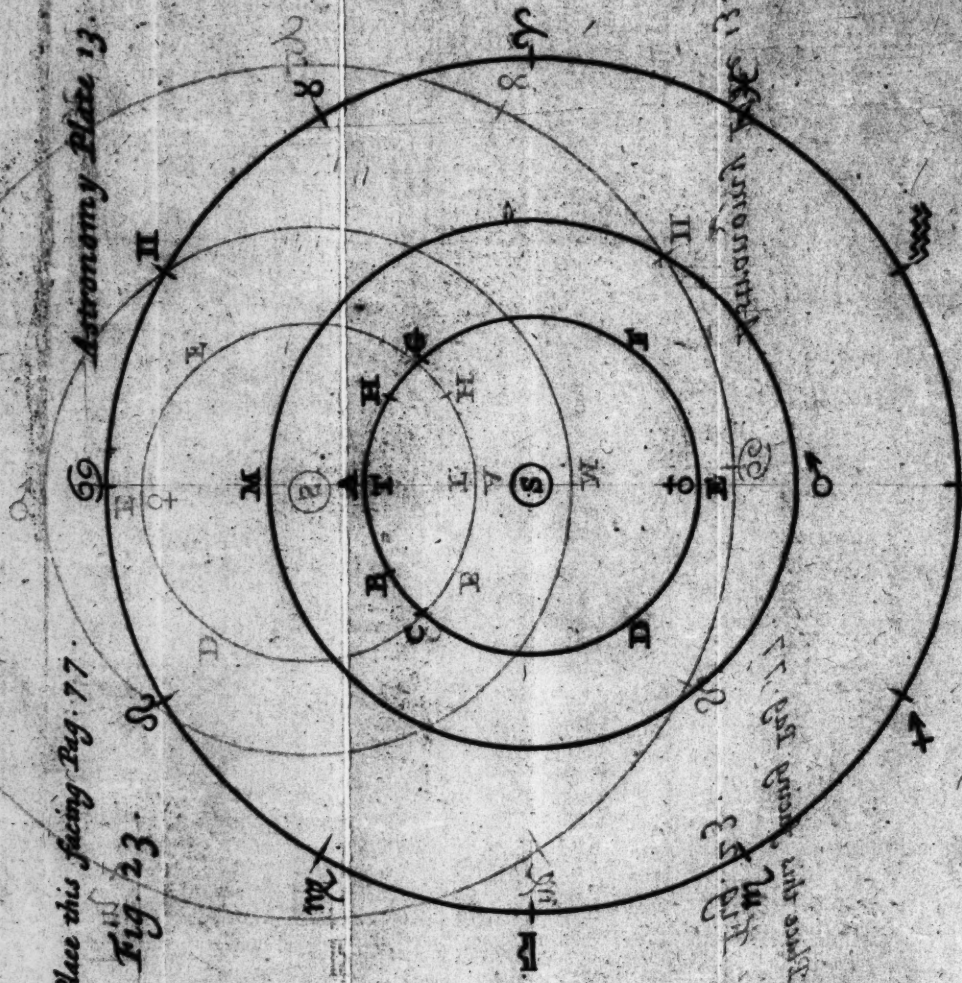
As the Agreement between the Phenomena of *Venus* and *Mercury* arises from their being both inferiour Planets.

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Fig. 23.

Astronomy Plate 13.

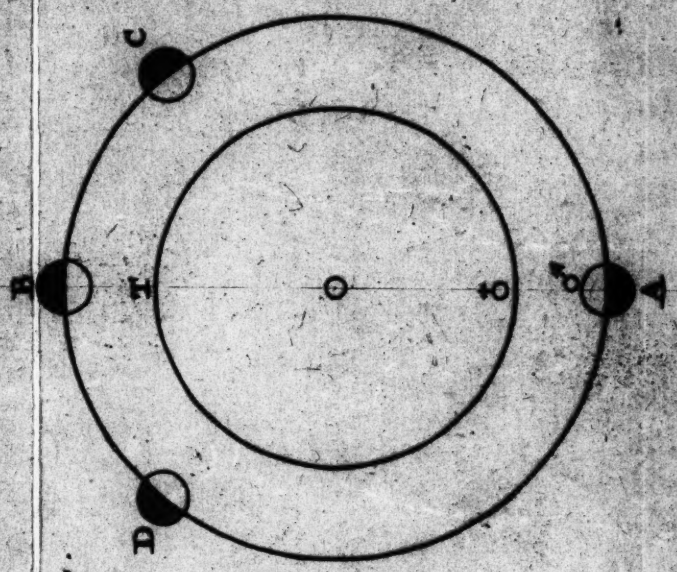


Place this facing Page 13.



Fig. 80.

Fig. 24.



nets to the Earth; so a like Agreement between the *Phænomena* of *Jupiter*, and *Saturn*, arises from their being superiour Planets to Earth.

Let then in *Fig. 23*, T & represent the Orbit of the Earth, M & the Orbit of (any superiour Planet, particularly) *Mars*. 'Tis evident, that *Mars* will not appear to us always accompanying the Sun, (as do the inferior Planets, *Venus* and *Mercury*;) but will appear sometimes as diametrically opposite to the Sun. For whereas the Earth goes round its Orbit sooner, than *Mars* does his; 'tis obvious, that the Earth will sometimes be in the Middle between *Mars* and the Sun; for Instance, while *Mars* is at M, the Earth may be at A.

Further, supposing *Mars* to be in B, and the Earth to be in B, *Mars* will appear stationary, for the Reason assigned, *Seç. 4*, concerning the Phenomenon of *Venus*. As the Earth moves from B through C, D, E, G to H, *Mars* will appear to move forward among the fixed Stars; with this Difference, that he will appear

the Phænomena the superiour Planets, arise from their Situation.

8.

The superiour Planet Mars appears sometimes Diametrically opposite to the Sun.

9.

The superiour Planet Mars, why appears sometimes to stand still, sometimes to move forward, sometimes backward.

appear to move quicker, when he is most remote from the Earth, and in Conjunction with the Sun, (i. e. when he and the Earth are so situated, as is represented *Fig. 23*, by supposing the Earth to be in DEF, and *Mars* in $\odot$ about M,) and slower, when he is situated with Respect to the Earth as M is represented *Fig. 23*, to be situated with Respect to either of the two Segments of the Earth's Orbit BC or GH. Whenever the Earth hath such a Situation to *Mars*, as it hath to M in *Fig. 23*, (which will be the Length be, forasmuch, as although *Mars* moves the mean Time round the Sun, the same Way as the Earth, or according to the Series of the Signs; yet the Earth moves faster, and so will overtake *Mars*,) the Planet *Mars* will again appear to stand still. And some short Time after will appear to go backward, or contrary to the Series of the Signs. For the Earth, as it moves from H through A to B, having overtook and gone beyond *Mars*, will make *Mars* appear to us to move contrary to the Series of the Signs, or from $\odot$ towards $\ominus$ &c. And in this Situation *Mars* appears

of Mars, Jupiter, and Saturn.

79

Mars opposite to the Sun, and also nearest, because it is then nearest to the Earth.

The like *Phænomena* happen to Jupiter and Saturn, save that the Retrogradations of Saturn are more frequent than those of Jupiter, and of Jupiter than those of Mars; forasmuch as the Earth does oftener overtake Saturn than Jupiter, and Jupiter than Mars.

10.
Jupiter and Saturn have the like fore-mentioned Phænomena with Mars.

'Tis obvious, that the Orbit of the Earth being nearer the Sun than the Orbits of the superiour Planets, none of these can hide the Sun from the Earth. But on the contrary, any of them may be hid by the Sun, while the said Planet is Direct, if it be but near enough to a Node.

11.
None of the superiour Planets can hide the Sun, but any of them may be hid by the Sun.

Lastly, Saturn and Jupiter appear to us with several Phases, but always with a full Orb; forasmuch that Hemisphere of each, which is toward the Sun, and so enlightened, is also always toward the Earth, the Earth being (comparatively) never far distant from the Sun, which is the center of the Orbits of Jupiter and Saturn. For the Distance of Jupiter from the Sun is above five Times, and

12.
Saturn and Jupiter, why appear always with a full Orb.

and that of *Saturn* almost ten Times greater than that of the Earth from the Sun.

13. But it is not so as to *Mars*. For the Distance of *Mars* from the Sun being but (*) half as much again the Distance of the Earth from the Sun, it follows, that the Hemisphere of *Mars*, which is towards the Sun will not always (so much as sensibly appear to) be toward the Earth. *Fig. 24.* let T be the Place of the Earth in its Orbit T δ , and the Circle ABCD denote the Orbit of *Mars*. 'Tis evident, that *Mars* being in A or B, (that is, either in Conjunction with, or in Opposition to the Sun) turns the same Face towards the Earth, as it does towards the Sun, and so shines with a full Orb. But in C or D the enlightened Face of Hemisphere of *Mars* is not all seen, but *Mars* appears a little defective in Light, in that Part of it which is from the Sun, and so appears gibbous. And thus we have solved at least the more remarkable Phenomena

Mars, why
not ap-
pears so
likewise.

(*) That is, as 15. to 10.

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Fig. 25.

Astronomy Plate 14

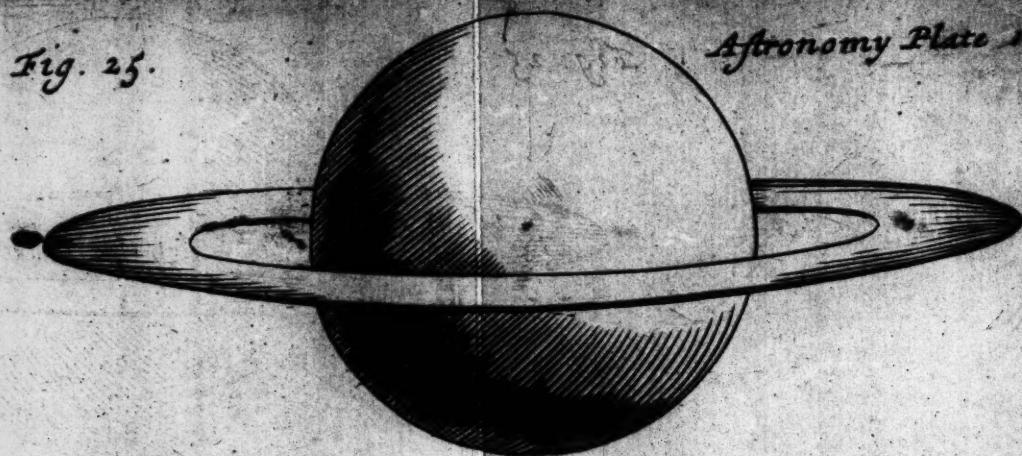


Fig. 26.

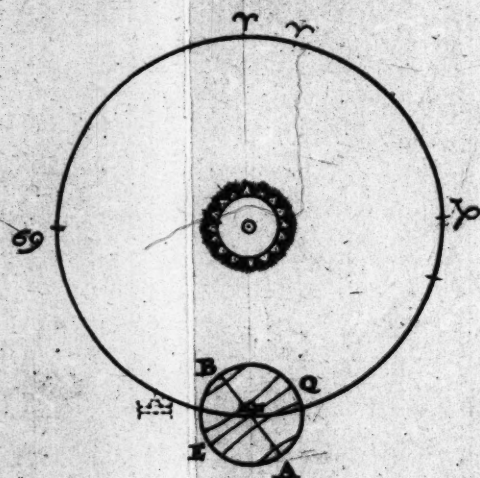
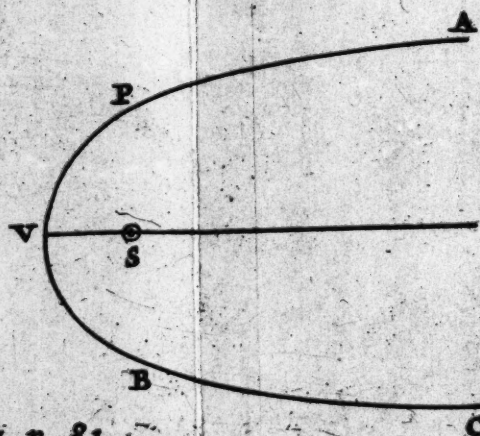


Fig. 27.



Place this facing p. 81.

Mars, Jupiter, and Saturn.

81

of the inferior and superior
primary Planets.

It remains only to add somewhat
concerning the *secondary* Planets, be-
cause what has been said of them,

in §. 1. And the first Particular that
deserves Observation, is this, that the
Phænomena to those which hap-

pen between the Earth and the Moon,
open between *Jupiter* and *Saturn*,
and their respective *Satellites*; foras-

much as the said *Satellites* are no
other than so many Moons in respect
to their respective primary Planet.

Hence, whenever either primary Pla-
net comes between the Sun, and
one of its respective *Satellites*, as

to hinder the Rays of the Sun from
falling upon it, it suffers an Eclipse.

And on the other hand, whenever
a *Satellite* comes so between the Sun
and its primary Planet, as to inter-

cept the Sun's Rays from its Primary,
the said Primary undergoes an Ec-

14.

The Sate-
lites of Ju-
piter and
Saturn un-
dergo Ec-
lipses,
&c.

The second Particular worthy of
Observation is the *Phænomenon* of Sa-

turn, which appears like an *Annulus*
ring, encompassing Saturn, as is
represented Fig. 25. From the vari-

15.

Of the An-
nulus or
Anſæ of
Saturn.

[G]

ous

ous Position of this *Annulus* in respect of the Sun and the Observer (it being opacous, like *Saturn* it self) arise the several Phases of (what they call) the *Anse* of *Saturn*, because they appear like the two Handles of a Cup, or the like. And this is sufficient to our present Design, concerning the inferiour and superiour Planets, as also concerning the *Satellites* of *Jupiter* and *Saturn*.

CH

C H A P. VII.

Of the Phenomena of the fixed Stars.

Having shewn how the Phenome-

na of the Sun, and Moon, and

planetary Stars may be solved, we

now proceed next to the Solution

of the Phenomena of the fixed Stars.

And these, not borrowing their Light

from the Sun, but shining with their

own native Light, are therefore not

subject to any such Deficiency of

Light, as is called an Eclipse.

It is indeed observed of (*) some

of the fixed Stars, that they do for a

certain Period appear, and then dis-

appear. Which Phenomenon is sup-

posed to arise from the said Stars

having some Macule or Spots, which

move round them in certain Periodi-

cal Times; as the Spots of our Sun

are observed to move round it. Nay,

1.

The fixed Stars not subject to Eclipses.

2.

Why some of them for a Time appear, and then disappear.

(*) Concerning such fixed Stars, see Dr. Gregory's
Phil. and Geom. Elem. Lib. 2. Prop. 30.

it is thought, that these Spots do sometimes grow so great, as to quite cover the Star to which they belong and so to make it disappear altogether; and that this is the Reason that several fixed Stars observed by the Ancients, are now not to be seen. And this Opinion is countenanced by the Observations that have been made, that sometimes a whole Year together our Sun has shone with more faint Light than at other Times this being supposed to be caused by the Spots of our Sun being for the Time grown greater than Ordinary.

3.
Of the different
Magnitude
of the fixed
Stars.

As to the fixed Stars appearing of different *Magnitudes* or Bigness to us this is ascribed vulgarly to their being really some bigger than others. But the more learned in *Astronomy* refer this apparent Difference of Magnitude only to their different Distances from us. As this Difference of Distance is sufficient to make some appear bigger, some lesser; so the Distance of the nearest to us being vastly great, hence our Sense of Vision cannot discern the different Distances, and consequently they appear to us as all placed in one and the same

the concave Sphere. By Reason of
 their apparent different Magnitudes,
 they are usually distinguished into six
 classes, being respectively called Stars
 the *First, Second, &c. Magnitude.*
 As to the Rising, Setting, and Re-
 volution of the fixed Stars round the
 Earth once in 24 Hours, it has been
 observed, that these *Phenome-*
na may be solved by the diurnal Re-
 volution of the Earth round its own
 Axis. But besides this apparent diur-
 nal Motion from East to West, the
 fixed Stars seem to have another Mo-
 tion, whereby they seem to move
 very slowly from West to East, or
 according to the Series of the Signs.
 This Motion is so very slow, that it
 is computed to require about 25 or
 thousand Years for the fixed Stars
 to seem carried thereby round the
 Firmament; whence it is stiled (*†*)
Annus Magnus, or the great Year.

4.
 The seem-
 ing proper
 Motion of
 the fixed
 Stars very
 slow.

It is also stiled *Annus Platonicus*, because the
 Philosophers teach, that every such Period Things are
 reduced to the same State and Condition, as they
 were so many Years afore.

[G 3] This

5.

The proper
Motion of
the fixed
Stars, not
Real, but
only Appa-
rent; and
whence it
arises.

This Motion is commonly esteem'd as the real proper Motion of the fixed Stars. But the more learned in Astronomy conceive the fixed Stars to have no such real Motion, as for other Reasons, so particularly for this, because the said Motion of all the fixed Stars may be more simply, compendiously solved, by the changing of the Places of the Equinoctial Points. For it comes to the same, whether we suppose the Equinoctial Points to be unmovable, the fixed Stars to move forward according to the Series of the Signs, or the fixed Stars to be unmovable and the Equinoctial Points to be moved backward, or contrary to the Series of the Signs. What has been said, is illustrated, Fig. 26, where γ $\ominus$ $\equiv$ ν represent the Orbit of Earth about the Sun, A E B Q Earth it self, γ and $\equiv$ the two Equinoctial Points for any one Year. Earth moving forward again from ν through ω towards γ , the Plane of the Terrestrial Equator being produced will pass through the Sun * at [

* Note, That these [γ] [$\equiv$] stand for prick'd γ and $\equiv$ in the Figure, the Types of which could not be had in Time.

fore that the Center of the Earth comes to γ . And in like manner, the Earth moving forward from γ through ϵ to α , the Plane of her Equator being produced, will pass through the Sun at $[\alpha]$, before that the Center of the Earth comes to α . But the Equinox will be then, when the Sun is found in the Plane of the Terrestrial Equator; and those Points of the Ecliptick are rightly esteemed the Equinoctial Points, wherein the Sun is seen at the two Equinoxes. Whereas, before, γ and α were the Equinoctial Points the last Year, the next year $[\gamma]$ and $[\alpha]$ will be the Equinoctial Points; and so the Equinoctial Points will go backwards, considered as to several Years. And by this Change of the Equinoctial Points, a fixed Star keeps its Place at that Point of the Ecliptick, which is denoted by α and where afore was the vernal Equinoctial Point, will now seem to be moved forward from the vernal Equinoctial Point to $[\gamma]$, as much as the Interval $\gamma[\gamma]$. Wherefore, this being the most Simple, and consequently the most natural Way of solving the Phenomenon we are speaking of, it is generally embraced now a-days.

[G 4]

And

And not only so, but it is, also mathematically demonstrated, what Reasons the *Equinoctial* Points do thus move backward, or the *Ecliptic* for every Year crosses the *Ecliptic* a little sooner or forwarder than did the last Year. Whence that which is commonly called the *proper Motion of the fixed Stars*, is now a-days taken by the learned in *Astronomy*, the *Precession* or *Anticipation of the Equinoctial Points*.

6.

The several Constellations, to which the more remarkable fixed Stars are reduced.

It remains only to set down Constellations, whereto the more remarkable of the fixed Stars are reduced. It has been shewn already what are the twelve Constellations Signs, whereby are comprehended the fixed Stars that lie in the *Zodiac*. In respect of which, the other Constellations are distinguished into northern or southern. The northern Constellations first distinguished by the Antients, are the *little Bear*, the *great Bear*, (or *Charleswain*), the *Dragon*, *Cepheus*, *Bootes*, the *northern Crown*, *Hercules*, the *Harp*, (or, as it is still

(C) See Dr. Gregory's *Astron. Lib. 1. Prop. 64.*

of the fixed Stars.

89

some, the *vultur Cadens*, the *man*, *Castropeia*, *Persens*, *Andromeda*, the northern *Triangle*, the *Charioteer*, the great *Horse* or *Pegasus*, the little *Horse*, the *Dolphin*, the *Arrow*, the *agle*, *Serpentarius*, the *Serpent*. To these 21 northern Constellations were afterwards added the Constellations *Antinous*, *Berenice's Hair*, and (by English) *Charles's Heart*. The southern Constellations known to the Ancients are the *Whale*, *Eridanus*, the *are*, *Orion*, the greater *Dog*, the *er Dog*, the *Ship*, the *Hydra*, the *ater* or two handed *Pot*, the *Ra* or *Crow*, the *Centaur*, the *Wolf*, the *Altar*, the southern *Crown*, the *ubern Fish*. To these 15 are not since added 12 Constellations, made up of the fixed Stars about the North Pole, and not visible to us, the *Phenix*, the *Crane*, the *Indi*, the *Peacock*, the *Apus*, the southern *Triangle*, the *Fly*, the *Chamaleon*, the *flying Fish*, the *Taucan* or *Ameri*, the *Goose*, the *Hydrus*, the *Dorado*, and the *Royal Oak*.

Besides these Constellations there are 7. Of the milky way. appears in the Heavens a certain tract, which goes quite round the Heavens,

Heavens, and from its appearing
be of a milky Whiteness, is call'd
Via () Lactea*, or the *milky Way*.
is now, by the Help of Telescope
discovered to be no other than
innumerable Multitude of little fix'd
Stars.

8.
Of the fix-
ed Stars,
called In-
formes.

Such fixed Stars as belong not
to this Milky Way, nor to any of
the Constellations, are called *Informes*,
not being yet reduced to any Form
or Image, as the Constellations are.
And so much for the fixed Stars.

(*) It is for the like Reason call'd *Galaxia* by
the *Greeks*.

C H A

C H A P. VIII.

Of the Phenomena of Comets.

Here remains now only the Phenomena of Comets to be solved, which are spoken of last, because there are not yet such Discoveries made, as afford the like Degree of Certainty in the Solution of the Phenomena of Comets, as there is in solving the Phenomena of the other Celestial Lights; as also because it is not known yet, whether Comets belong only to this our Solar System, whether they may not also pass to other of the Mundane Systems, which have the fixed Stars for their several respective Suns. It is supposed most probable by the Learned in Astronomy, that they move in some conick Section, which has the Sun in one of its Focus's. For this Sort of Orbit is found best to agree to the Observations that have been made concerning the Motion of Comets. Some indeed have formerly thought,

1.

Comets, why treated of in the last Place.

2.

Comets supposed to move in some conick Section.

thought, that they move in right Lines; and some Calculations that have been made concerning their Motion, have agreed well enough to the Hypothesis. But then it is to be noted, that this will hold the farther although Comets move in a conick Section, if so be the Observations made in that Part of their Orbit which comes very near to a right Line. Let $APVB$ in Fig. 27, be a conick Section very eccentric, and let one of its Focus's be S the Centre of the Sun. It may be, that the Comet may be observed, whilst it is moving along the Part AP of its Orbit; and the rest of the Time whilst it moves from P through V to C , it may be hid from us by the Rays of the Sun. Or the Comet may be so hid from us, whilst it moves along $APVB$, and may be then observed, when it is come to B , as it is about to describe the Line BC . In both these Cases, the Line described by the Comet will not be sensibly different from a Right Line. Moreover the Comet being observed in his Descent towards the Sun, then drawing daily nearer to the

Of Comets

23

after that lying hid for some
 time under the Sun's Rays, and at
 length getting again out of the Sun's
 Rays on the other Side of the Sun;
 when it comes to pass, that one and
 the same Comet is looked upon to be
 different Ones, which both move
 in right Lines, viz. one in A P,
 the other in B C. Whereas in reality
 they may be all the while one and the
 same Comet, whose Trajectory (or
 that which it describes by its Mo-
 tion) if considered together, both as
 its Descent toward the Sun, and
 its Ascent from the Sun,
 will be found to be one and the
 same conick Section, as was afore-
 said. Now of the three conick Sections, the
 Ellipsis is found most agreeable to the
 Motions (as of the Planets, so also) of
 Comets. And it can be no other
 than Bodies of a lasting Sub-
 stance, as are the Planets, and like
 them have a Periodical Motion round
 the Sun. If Comets have not such a
 Periodical Motion, then their Tra-
 jectory is Parabolical, or Hyperbo-

3.
 Comets
 supposed to
 move in
 that conick
 Section,
 which is
 called an
 Ellipsis.

Some

4.
The vari-
ous Moti-
ons, &c.
of Comets.

Some Comets move like the Planets, from West to East; Some from East to West; others from North to South, and others lastly from South to North. And their *Orbits*, as to Greatness, Situation, and Inclination, as well in Respect to one another, to the *Orbits* of the Planets, are various and different.

5.
Comets
consist of
two Parts,
an Head
and Tail.

Lastly, A Comet does visibly consist of two Parts, one called the *Head*, the other called the *Tail*. The *Head* is the Solid Body of the Comet, it is opacous, as appears from the Shadow it casts. The *Tail* is conceived by the Learned to be no other than thin Vapour arising from the *Head* by Heat. Namely, whilst the Comet is descending to its *Perihelium*, the Vapours which had afore settled it, when it was in the Regions remotest from the Sun, being now melted by the Heat of the Sun ascend, i. e. fly off that Way which is from the Sun. Hence it comes to pass, that the *Tail* of a Comet grows greater and greater, as the Comet approaches nearer and nearer to *Perihelium*; and on the other hand the *Tail* grows less and less, as

Comet goes further and further from the Sun; and consequently the Tail greatest and most shining, presently after the Comet has been most heated at its *Perihelium*. And thus it has been shewn, how the more remarkable *Phænomena* of the Celestial Bodies may be solved or explained according to the *Copernican Hypothesis*.

CHAPTER.

C H A P. IX

A Description of the Celestial (also Terrestrial) Globe.

I.

The Celestial Phenomena are represented by artificial Machines, the chief whereof is the Globe or Sphere.

2.

The import of the Words, Sphere and Globe.

IN the foregoing Chapters, the Celestial Phenomena have been treated of, as considered in themselves, proceed now to treat of them, they are represented by artificial Instruments and Machines, among which the chief is the Sphere Globe.

The Word *Sphere* we borrow from the Greek Language, as we do the Word *Globe* from the Latin; each Word, in its respective Language answering one to the other, and denoting a round Body, that is, according to the Mathematical Definition thereof, a Body from whose innermost Point, called its Center, all right Lines drawn to its Surface are equal one to the other. But the Word *Sphere* is now a-days commonly used to denote a Machine somewhat different from a Globe, and more cultivated

early stiled an *Armillary Sphere*; as much as it does not consist of a continued Surface, but only of Circles duly placed together, fancied to resemble *Armilla*, i. e. *belets*.

The Sphere and Globe are made to represent principally such *Phænomena*, which arise from the Diurnal Motion. Hence that Part of *Astronomy*, which treats of the diurnal Motion, is frequently stiled (*) *Spherical Astronomy*, or the *Doctrine of the Sphere*. In like manner, the other Part of *Astronomy*, which treats of the annual and proper Motion, is stiled *Theoretical Astronomy*, from the Schemes or (as it is called) little Paper Machines, formerly used to illustrate the (†) Theory of the said proper Motion, and thence *Theoria*.

There are Spheres made agreeable to the *Copernican Hypothesis*, and others made agreeable to the vulgar

3.
Spherical
and Theo-
rical A-
stronomy,
what, and
why so cal-
led.

4.
The com-
mon Cele-
stial Globe,
how far
useful in
Astronomy.

This makes the first Part in common *Astronomy* practical, and *Theoretical Astronomy* the second

is originally a *Greek Word*, denoting *Speculation* or *Contemplation*.

[H]

or

or *Ptolemaick* Hypothesis. But the former Sort being very costly, the latter Sort being not of so great Use (even in their own Way, according to the *Ptolemaick* Hypothesis) as the Artificial Celestial Globe, this is most commonly made use of to illustrate to young Students the Celestial Phenomena. And when they have been once set right as to the true System of the World, and the Causes of the said Phenomena, having had the *Copernican* Hypothesis explained to them; then it is possible for them to make Use of a common Celestial Globe, though it represents the Celestial Phenomena not according to their real Natures, but only according to their Appearances: forasmuch as it is convenient not to say necessary, in common course to talk of the celestial Phenomena according to the common Notions of them, i. e. according to their Appearance to our Senses, from which the Vulgar derive their Notions.

5.

On Account
of such its
Usefulness,
the Cele.

On these Considerations, have the eight foregoing Chapters of this Treatise explained the real Natures and Causes of the Celestial Phenomena.

I shall in the remaining Part of this Treatise shew, how the said *phenomena* are represented by the Celestial Globe, as to their Appearance to our Sense. And therefore I will first (in this Chapter) describe the artificial Celestial Globe, and then in the following Chapter) shew the use thereof.

stial Globe is here treated of, and described.

Among the several Circles belonging to the celestial Globe, I shall begin with the *Horizon*; forasmuch as the artificial *Horizon* is the outermost Circle of the artificial Globe, and which encloses and upholds all the rest of the said Globe.

6.

Of the Horizon of the Celestial Globe:

As has been (||) afore observed in the last Chapter, that the *Horizon* is so called, because that Circle which bounds the Sight. To which it is further to be added here, that the *Horizon* is distinguished by *Astronomers* into the *sensible* and the *rational Horizon*.

7.

The Horizon two-fold, Sensible and Rational.

For a right and clear Apprehension of the sensible *Horizon*, it must be called to Mind, that the Sight, if not hindered, extends it self equally every Way.

8.

The sensible Horizon, what, and why so called.

Hence it comes to pass, that, when we stand upon the Surface of the Earth, and the Eye has a free View all round, so much of the Heavens as is seen, appears to us under the Figure of a concave Spherical Surface reaching to the Surface of the Earth. The seeming Intersection or Meeting of the Surface of the Earth with the fore-mentioned concave spherical Surface of the Heavens, being continued every Way round the Eye, represents a Circle, which is called (by a Greek Word) the *Horizon*, because it bounds the Sight, and divides the seen Part of the Heavens from the unseen; and it is particularly stiled the *sensible Horizon*, because it does thus actually fall under our *Sense* of Vision, where the Eye has a (*) free View.

9. The *rational Horizon* is so called because it falls not under our Sense of Vision, but is only to be conceived by our *Reason*. For hereby is denoted that *Horizon*, which would bound the Sight, supposing the Earth bisected.

The rational Horizon, what, and why so called.

(*) Hence it is observable, that every *Horizon* actually bounds the Sight, is not properly the *sensible Horizon*.

and one Half of it removed, and the Spectator placed on the Center of the Earth. What has been said of the *Horizon*, is illustrated *Fig. 28*, where the greater Circle denotes the Heavens, the little Circle, the Earth, the Line drawn through P the sensible *Horizon*, the other Line the Rational. Hence it is also evident, that the sensible *Horizon*, and its respective Rational *Horizon* are always parallel to the other, and that their mutual Distance is the Semi-diameter of Earth.

Now the whole Earth being but as a Point in respect of that vastly distant Sphere, wherein the fixed Stars are to be all placed; hence the Distance between the rational and sensible *Horizon*, being no more than the Semi-diameter of the Earth, makes a sensible or considerable Difference to the *Phænomena* of the fixed Stars.

10.
The Earth, but as a Point in respect of the Sphere of the fixed Stars.

But the Distance between the rational and sensible *Horizon*, bears a considerable Proportion to the Distance of the other celestial Lights from Earth, and consequently makes a con-

11.
Of the Parallax of the Celestial Lights.

a considerable Difference as to the
 (†) Places of these other celestial
 Lights, which are between the Earth
 and the fixed Stars. This is
 illustrated *Fig. 28*, where the out-
 most Semi-circle represents Half
 Sphere of the fixed Stars; the other
 two Semi-circles represent the Half
 of the *Orbits* of any two celestial
 Lights between the Earth and
 fixed Stars; and the little Circle
 about the common Center of the for-
 mentioned Semi-circles represents
 Earth. The Lines drawn from
 (the Place of the Spectator) on
 Surface of the Earth, through
 Centers of the Celestial Lights
 and S, to the Sphere of the fixed Stars,
 do there denote the *apparent Place*
 of the said celestial Lights; and
 other Lines drawn from the Center
 the Earth, through the Centers
 M and S, to the Sphere of the
 Stars, do there denote (what are

(†) Here must be remembered what is said
 i. *Señ. 15.* viz. That that Point or Part of the
 of the fixed Stars, between which and the Spectator
 any other of the Celestial Lights appears to
 counted the *Place* of the said Celestial Light.

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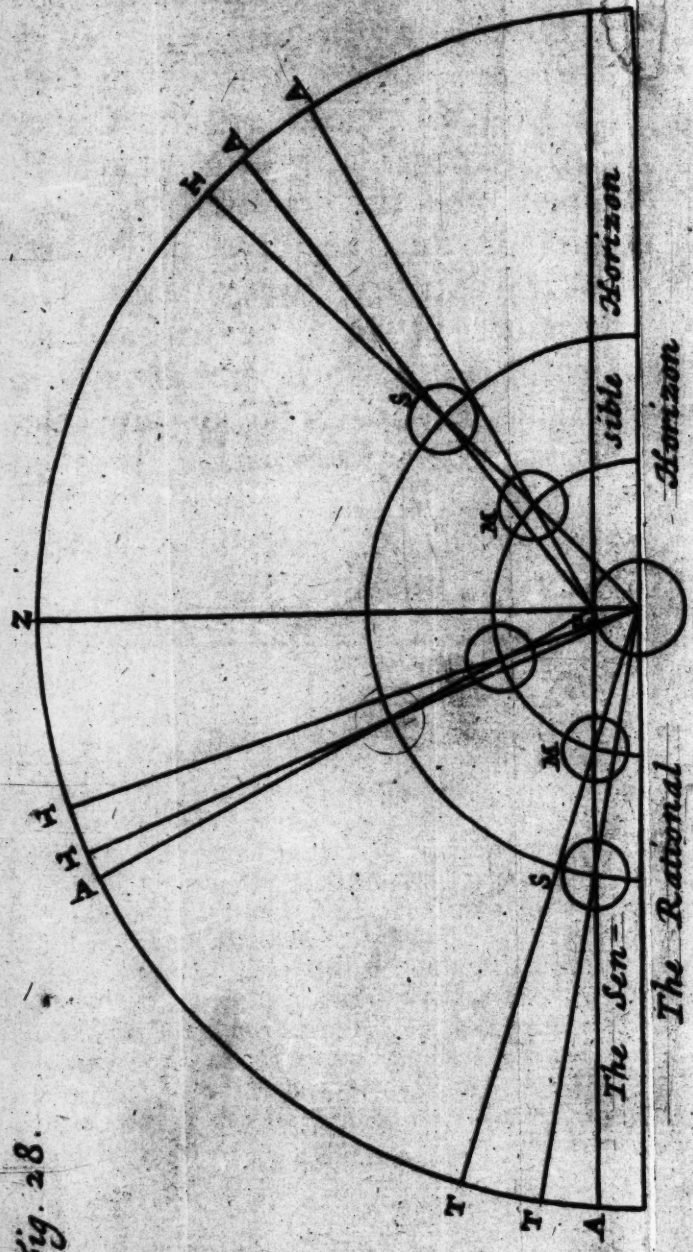
the

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to

t.

Fig. 28.



Horizon

The Rational

Place this facing p. 103.

the true Places of M and S. Hence may be learned, the Reason thus taking Notice of the Rational Horizon, forasmuch as *that* is esteemed Astronomers, the true Place of a Phenomenon, where (it would be seen a Spectator placed on the Center of the Earth, *i. e.* where) it is with respect to the rational Horizon. Thus T is the true Place of M and A the apparent Place of each. The Difference between the true and apparent Place (which are always in the same vertical Circle) of any celestial Light or Phenomenon, is called (II) *Parallax*.

Having

It is a Greek Word signifying a Variation or Difference. It seeming too long a Digression to introduce the Body of this Chapter an Explication of *Parallax*, and on the other hand the *Parallax* being a Particular too material to be only mentioned, I judged it best to adjoin here by way of Note, what seems requisite to be said of it. The *Parallax* may be considered, either with Respect to different Celestial Lights, or the same. In the former Respect, the *Parallax* is greater or lesser, as the Celestial Bodies are less or more distant from the Earth: Thus the *Parallax* T A of M, is greater than the *Parallax* T A of S. And hence the Moon has the greatest *Parallax*, as being nearest of all the Celestial Lights.

12.

The Horizon of the Globe represents principally the rational Horizon.

Having shewn the Difference between the sensible and rational *Horizon*, and withal taken Notice, that is the rational *Horizon*, which is principally regarded by *Astronomers*, next to be observed, that according to it is the rational *Horizon*, which principally

Lights to the Earth. In respect of the same celestial Light, its greatest *Parallax* is at the *Horizon*, and as the Celestial Light ascends higher and higher above the *Horizon*, so its *Parallax* continually decreases, till it quite ceases in the *Zenith* or *Vertex* Point. For there the two Lines which mark the apparent and true Place, do fall in together, as is evident from *Fig. 28*. What more seems requisite here observed, is that the Angle made by the meeting of the two Lines just mentioned in the *Zenith* of the Celestial Light, is called the *Parallax Angle*, or the *Angle of the Parallax*, and by it the *Parallax* is measured; as also that the apparent Place is always lower or nearer to the *Horizon*, than the true Place. Whence the *Parallax* has a quite contrary Effect to *Refraction*; forasmuch as this causes a *phenomenon* to appear higher, or more above the *Horizon*, than really it is. Thus in *Fig. 29*, let *T* denote the Earth, surrounded with the Atmosphere *A*, and *S* some Star, and *O* the Spectator on the Surface of the Earth. Were there no Atmosphere, or were it of equal Thickness with the *Aether*, the Rays of Light would come directly or in a right Line from *S* to *O*. But the Rays, when they have passed through the *Aether* *SQ*, entering at *A* into the Atmosphere, which is thicker than the *Aether*, hereby is refracted (as it were broken) and bent towards the right Line *QO*, which is perpendicular to the Surface of the Earth.

A

Fig

Fig

HORI

Place

Fig. 29.

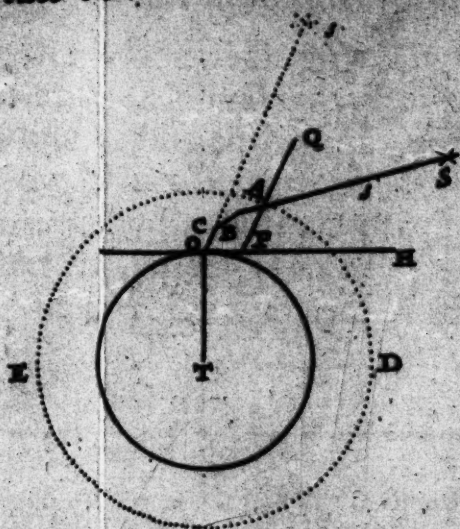
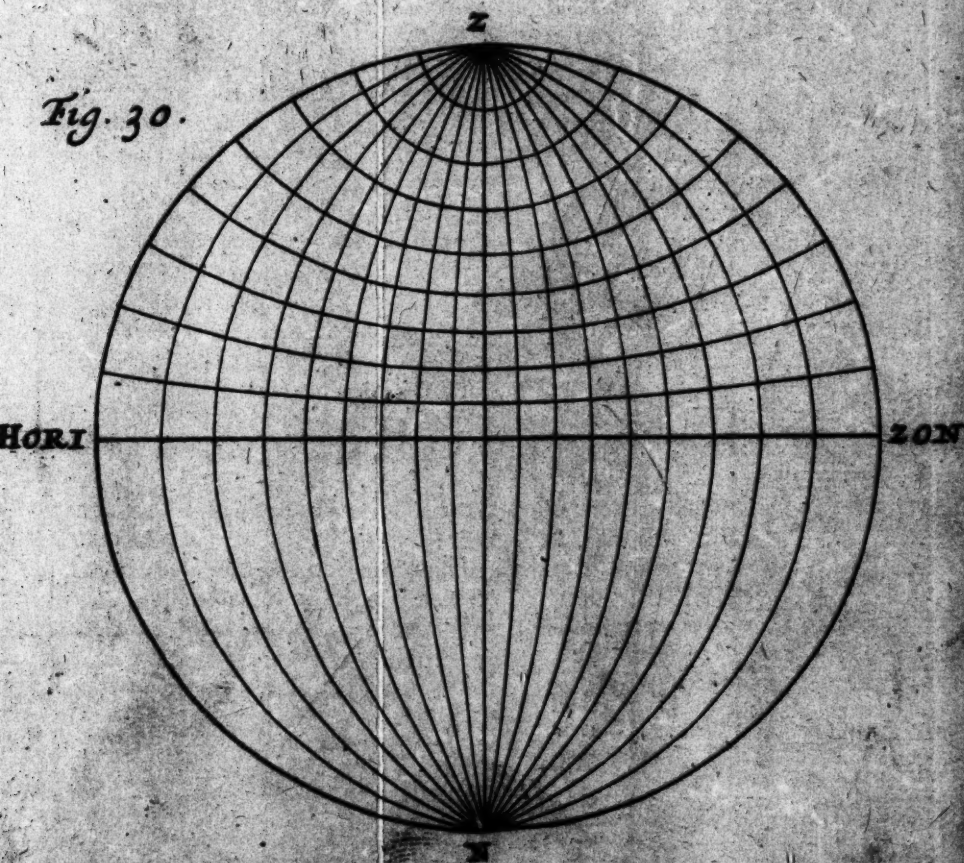


Fig. 30.



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Star S
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principally represented by the artificial Horizon of the Globe; which therefore is (or at least ought to be) placed, as to divide the Globe it self exactly into two Hemispheres or equal Parts. But here it is to be re-

sphere at A. And because it is likely, that the Atmosphere it self is not all along, from the *Ether* to Earth, of an equal Thickness, but is thicker, as nearer to the Earth; hence a Ray coming from Star S will be refracted, not only at A, but also at other Points within the Atmosphere, (as at B, C, &c.) and at each of these Points will be refracted the same Way, viz. toward T. But of the Ray CO, it is only the last Part CO, which affects the Eye; and therefore the Eye sees the Star at S, consequently much higher, or much more above Horizon OH, than really it is. But Refraction (as *Parallax*) is greater, when the Phenomenon is nearer to the Horizon; and as the Phenomenon ascends, it continually decreases, and quite ceases in Zenith. To Refraction it is attributed, that the Sun and Moon appear of an Oval Figure near the Ho-

For the upper Rim of the Sun and Moon appearing a little higher, and the lower Rim a great deal higher than it really is, hence this will seem nearer to that than it really is; and so the erect vertical Diameter of either Luminary will seem contracted, while the transverse or horizontal under no such Contraction, forasmuch as its Extremities are alike elevated by Refraction. 'Tis also to the Refraction of the Sun's Rays to the Atmosphere, that the *crepusculum* or *Twilight* is owing; for otherwise, as the Sun is set, it would be presently quite dark. By Refraction also the Sun and Moon appear above the Horizon, when their Bodies are somewhat below the Horizon.

marked,

marked, that although the whole broad wooden Circle, which encompasses the Rest of the Globe, is sometimes be called the *Horizon* of the Globe, yet properly and strictly it is only the inner Rim or Edge of the upper Surface of the said broad wooden Circle, that is the *Horizon* of the Globe, and (*) represents the true *Horizon*, whether Rational or Sensible.

13.
Of Almucantars,
the Zenith
and Nadir.

For the Measuring of the Altitude or Depression of any Phenomenon (i. e. its Distance above or below the *Horizon*,) there are conceived several Circles to run parallel to the *Horizon* through every Point of the Globe, which (as is illustrated Fig. 30,) grow less and less on each Side of the *Horizon*, as they are more remote from it, and at length End in two Points. One of these Points being always

(*) The *Horizon* (as is above observed) is that circular Line, wherein the Surface of the Heavens and the Surface of the Earth intersect, or are conceived to intersect, one the other. This circular Line has only a circular Length, no Breadth nor Thickness. And therefore it is properly the inner Edge of the upper Surface of the broad wooden Circle, which is the artificial *Horizon* of the Globe.

ver the Vertex or Head of the Spectator, is therefore called the *vertical Point*, or by a single *Arabick Word*, the *Zenith*. The other Point, which is diametrically opposite to the former, is called by an *Arabick Word*, the *Nadir*. The *Zenith* is represented in Fig. 30, by the Point Z, the *Nadir* by the Point N. The fore-mentioned parallel Circles between the *Horizon* and the *Zenith* or *Nadir*, are called from their Use, *Circles* or *Parallels of Altitude*, and by an *Arabick Word*, *Almicantars*.

For denoting what Point of the *Horizon* any *Phenomenon* is in, or is at least to be referred to, there are conceived also *Circles* crossing every Point of the *Horizon* at right Angles, and all crossing one another in the *Zenith* and *Nadir*. And from their common Intersection being thus in the *Zenith* or vertical Point, they are called *vertical Circles*, or by an *Arabick Word*, *Azimuths*. These are also illustrated Fig. 30.

14.

Of Azimuth's or Vertical Circles.

Among the Points of the *Horizon* there are four, which are called the *Cardinal* (i. e. Principal) Points, and are distinguished by the Names of the

15.

Of the four Cardinal Points of the Horizon.

East

East, West, North, and South Points. The east and west Points of every *Horizon* are those, wherein the Sun rises and sets, when he is in the *Equinoctial*. The other two are each 90 Degrees distant from the former one towards the north Pole, and thence called the north Point; the other toward the south Pole, and thence called the south Point.

16.
Of the
prime
Vertical
and Meri-
dian.

Among the vertical Circles, there are two of special Note, which pass through the Cardinal Points of the *Horizon*. That which passes through the east and west Points is called the *prime Vertical*; the other which passes through the north and south Points is stiled the *Meridian*, because every Day, when the Sun comes to that Circle, it is then *Meridies* or Mid-day within that *Horizon*. When any celestial Light is risen, it ascends still higher and higher, till it comes to the *Meridian*; and as soon as it has crossed that, it begins to descend lower and lower. Hence, when it is at the *Meridian*, it is said to *culminate*, (i. e. to be at its *Culmen* or Top-height for that Day,) and so

greatest Height is therefore called
meridian Altitude.

As the *Horizon* divides the World
to an upper and lower (or visible
and invisible) Hemisphere; so the
Meridian divides the World into an
Eastern and western Hemisphere; the
former being so called, because it is
that wherein the celestial Lights do
set; the other, because it is that
wherein they set.

Though the whole brass Circle,
which is immediately upheld by the
Horizon at its north and south Points,
is frequently called in gross the *Me-
ridian of the Globe*; yet properly and
strictly speaking, the artificial *Meri-
dian* is only the graduated Edge of
said brass Circle.

The *Meridian* is the only vertical
Circle, which is distinctly represented
on the Globe. As for all the rest,
they are represented in Part by the
Quadrant of Altitude respectively ap-
plied to the Body of the Globe, from
the *Zenith* to the *Horizon*. It is a
very narrow Strip of Brass, made
such, that it might be pliant to the
Curvature of the Globe; and made to
reach from the *Zenith* to the *Horizon*,
so

17.

*The upper
and lower,
eastern
and west-
ern Hemi-
spheres,
what.*

18.

*The Meri-
dian of
the Globe,
what.*

19.

*Of the
Quadrant
of Alti-
tude.*

so much of it as is contained between the *Zenith* and *Horizon*, being divided into 90 Degrees, as being just equal to the fourth Part of the Circumference of the Globe; whence it takes the Name of the *Quadrant*, being peculiarly styled the *Quadrant of Altitude*, from its Use in taking the Altitude of any Point of the Globe. And as the Strip of Brass so called does by its Length from the *Zenith* to the *Horizon*, represent the fourth Part of a vertical Circle; so being rightly fastened on Top at the *Zenith* and then moved round the Body of the Globe, by such its Motion, several Points thereof will represent the several *Almicantars* between *Zenith* and *Horizon*.

20.
of the
Axis, and
Poles of
the World,
in the
artificial
Globe.

Within the brass Circle called *Meridian* of the Globe, hangs the Body of the Globe, being upheld by two Iron (as it were) Pins fastened to the *Meridian*, the Body of the Globe being made to turn round upon the two Pins, which therefore represent the *two Poles of the Equator*, or they are otherwise called) of the

(†) They are so called, because all the World the Earth seems to turn round upon them.

Wor

Of the Celestial Globe, &c.

rrr

world; that by the little Bear on the face of the Globe, representing the Arctick or north Pole; and the other, the Antarctick or south Pole. The Piece of Iron passing through the Center of the Globe, and of which two Iron Pins afore-mentioned the Extremities, represent the Axis of the World.

From what has been above said, Chap. III. Sect. 5.) it is obvious,

that the Equator of the Celestial Globe is the great Circle, drawn on the Surface of the Globe in the very middle between the two Poles already mentioned; as also, that the great Circle, which crosses obliquely the Equator, is the Ecliptick of the Globe; and that the two lesser Circles, which the said Ecliptick touches at its greatest Declination (northward southward) from the Equator, are the two Tropicks of the Globe; that on the north Side of the Equator, the Tropick of Cancer; that on the South Side, the Tropick of Capricorn; lastly, that the two lesser Circles drawn on the Surface of the Globe at the same Distance (*viz.* $23\frac{1}{2}$ Degrees) from each Pole of the Equator, as the Tropicks

21.

Of the Equator, Ecliptick, two Tropicks, and polar Circles of the artificial Globe.

picks are from the *Equator* it self, the *polar Circles* of the Globe; that about the Arctick or north Pole, the *Arctick Circle*; that about the Antick or south Pole, the *Antarctick Circle*.

22.
The Equator always bisected by the Horizon.

In reference to the *Equator*, it here to be added, that whereas it has been afore in this Chapter Set. observed, that the east and west Points of any *Horizon* are those where the Sun rises and sets, when he is in the *Equator*; and when also it is then equal Day and Night all over the World; it hence follows that the artificial *Equator* in any Position of the Globe, must cut the *Horizon* exactly in its east and west Points; and there cut it so, as to be equally divided by the *Horizon* into two Parts, one Half being above the *Horizon*, the other below. And these Particulars it may be further proved, when a Globe is truly made.

23.
The Position of the Equator to the Horizon three-fold.

The Position of the *Equator* to the *Horizon*, is in general three-fold. The *Equator* cuts the *Horizon*, either at right Angles, or at oblique Angles, or else it is *Parallel* to the *Horizon*.

Such as live under the celestial (or
 which is the same, upon the ter-
 rial) *Equator*, their *Horizon* is
 bisected by the *Equator*, and conse-
 quently by all its *Parallels* at right
 angles; and hence these are said to
 live in a *right Sphere*. The Property
 of which Sphere is this, that it is
 therein equal Day and Night through-
 out the whole Year. For the *Equator*
 and all its *Parallels* being bisected by
 the *Horizon* in a *right Sphere*, (as
 may be shewn by putting the mecha-
 nical Globe into such a Position, viz.
 that the *Equator* of the Globe
 may move round under the *Zenith*,)
 the Sun's diurnal Motion being
 always either in the *Equator*, or one
 of its *Parallels*; hence it follows, that
 the Sun (moving all the 24 Hours
 of the day) must always make as long a
 day above, as below the *Horizon*,
 in a *right Sphere*; and consequently,
 it must be there equal Day and
 Night through the whole Year.

24.
 Of a right
 Sphere.

Such as live on either Side the
Equator, between it and its Poles,
 their *Horizons* do cross the *Equator*,
 consequently its *Parallels*, at An-

25.
 Of an ob-
 lique
 Sphere.

[1]

gles

gles less or more oblique, according as they live less or more distant from the *Equator*. Hence these are said to live in an *oblique Sphere*, and the *Horizons*, though they all bisect *equally* divide the *Equator* it self, yet do all less or more *unequally* divide its *Parallels*, according as the *Parallels* themselves, and the *Places* in which the *Horizons* respectively *rise* long, are less or more distant from the *Equator*. Wherefore, the diurnal Motion of the Sun, when it is not in the *Equator*, being in some one of its *Parallels* thus less or more *unequally* divided by the respective *Horizons*, it thence comes to pass, that the *Day* and *Night* are less or more *unequal* at the *same Time* of the *Year* (excepting the two *Equinoxes*) in *different Places*, according as the *Places* are less or more distant from the *Equator*; and also, that the *Day* and *Night* are less or more *unequal* at *different Times* of the *Year* in the *same Place*, according as the Sun is less or more *Distant* from the *Equator*. All which is evidently to be shewn upon the *Globe*.

Lastly, Under the very Poles of the Equator, or of the World, the Horizon and Equator run parallel one to the other, which Position is therefore called a *parallel Sphere*. The property of this Sphere is, that there it is Day for Half the Year together, and Night for the other Half. For the Equator and Horizon being parallel, as long as the Sun stays on the same Side of the Equator, so long must it stay above the Horizon at that Pole, and consequently, so long together is it Day at the respective Pole, and Night at the opposite Pole. This is also evidently shewn upon the Globe, being placed so as that its Equator and Horizon become parallel one to the other.

26.
Of a parallel Sphere.

It remains to observe in reference to the Equator, that a Revolution thereof is the Measure of a (H) *Nachthemeron*, or the Space of 24 hours. Accordingly, whilst any part of the artificial Equator moves

27.
The Revolution of the Equator, the Measure of a Nachthemeron, or of 24 Hours.

(H) It is a Greek Word signifying the Space of one Day and Night taken together.

[1 2]

from

from the artificial *Meridian* round the same Side of the said *Meridian* again; the Index, which is fastened to the north Pole of the Globe, will move quite round the Hour-circle fastened upon the *Meridian* about said Pole. And by comparing the Motion of the *Equator* with that of the Hour-Index, it will sensibly appear, (if the Globe be made true) that as the whole Circumference of the Heavens, divided into 360 Parts called Degrees, pass under the *Meridian* of any Place in a *Nutchment* or 24 Hours; so 15 Degrees of the Circumference of the Heavens pass under the same *Meridian* every Hour. For according to the Rule of Proportion, as 24 Hours, are to 360 Degrees, so 1 Hour, is to 15 Degrees.

28.

The Zodiack, why divided into twelve Signs, and each Sign into thirty Degrees.

Proceed we next to observe in reference to the *Zodiack* or *Ecliptic* that, the Reason, which induced the Old *Astronomers* to divide it into twelve Signs, is thought to be (*)

(*) Some conceive the Reason to have been, that the Number *Twelve* has many aliquot Parts.

ally this; viz. because the Moon
 goes twelve Times round the *Zodiack*,
 whilst the Sun goes once. And for
 the like Reason it seems to be, that,
 whereas one Revolution of the Sun
 round the *Zodiack*, is called the *Solar*
 Year, there are reckoned twelve Re-
 volutions of the Moon round the
Zodiack to make up the *Lunar Year*.
 Lastly, The Reason why each Sign of
 the *Zodiack* was distinguished into
 thirty Degrees, seems to be this, be-
 cause the Moon always overtakes the
 Sun in (†) about thirty Days after
 he has left him.

And because the Sun *graditur*, i. e. ^{29.}
 goes, in a Day and Night or 24 ^{Degrees,}
 hours Space, near upon one of these ^{whence so}
 thirty Parts of a Sign; hence the said ^{called.}
 parts are thought to be stiled by the
 Latins *Gradus*, and so by us *Degrees*.
 And from the Circle of the *Zodiack*,
 more particularly of the *Ecliptick*,
 came this Name to be transferred to
 the like Divisions of all, not only
 Astronomical, but also other mathe-
 matical Circles.

(†) See Chap. 4. Sect. 3.

30.

*How to
find on the
Globe,
what Sign
answers to
each Ca-
lendar
Month.*

Agreably to the 12 Signs of the *Ecliptick*, the Solar Year is also divided into twelve Months, called Solar Months; each being the Space when in the Sun goes through a Sign, and so containing almost 30 $\frac{1}{2}$ Days. Hence these Solar Months strictly so called, answer to the common Calendar Months, or (which amounts to the same) what Degree of the *Ecliptick* the Sun is in each Day of the 12 Calendar Months, is to be seen on the upper Surface of the broad wooden Circle of the Globe, commonly called its *Horizon*; for thereon the 12 Signs of the *Ecliptick*, and the 12 Calendar Months are so placed, both according to the *Julian* and *Gregorian* Accounts, as that the Days of these may correspond answer to the respective Degrees of those.

31.

*The Divi-
sions of the
Zodiack
or Eclip-
tick are to
be known,
not by the
Constella-
tions or
Signs
themselves.*

In reference to the 12 Divisions of the *Ecliptick* on the Surface of the Body of the Globe, it is to be observed, that neither the Constellations themselves, nor their Names, nor their Characters shew, which Division of the *Ecliptick* is esteemed respectively to belong to each Sign,

comes under the Name of each Sign. Thus the Character γ is placed at the Beginning of that Division, which is esteemed to belong to *Aries*; and the said Division of 30 Degrees between γ and δ , is that which is denoted by the Sign of *Aries*; whereas the Constellation so called, is now, great or most Part out of that Division; and the Word *Aries* is affix'd to the said Constellation almost at the End of the said Division. So the Division between π and ϵ , is that which is denoted by the Sign of *Gemini*, though the Constellation so called, is almost entirely out of that Division, and consequently, the Word *Gemini* affixed to the Constellation.

The Reason hereof is this. The Constellations themselves (||) continually (though very slowly) changing their Situation in the *Zodiack* or *Ecliptick*, in Conformity thereto, continually to change the Names of the several Divisions, would create great

selves, but
by their
Chara-
cters.

32.

And the
Reason
thereof.

(||) To what this Change of Situation is owing, is observed, Chap. 7. Sect. 5.

Confusion in *Astronomy*; forasmuch as it would make it an intricate Matter, rightly to distinguish what Part of the *Zodiack* belonged to the several Signs in different Ages of the World. Wherefore to avoid such Confusion, it has been with great Prudence judged Expedient, not to make any Change as to the Names of the Divisions, though the Constellations themselves do in Process of Time change their Places; but always to look on that which is esteemed the first Division of the *Zodiack* belonging to *Aries*, at least to let it go always under the Name of *Aries* (and so of the rest) though that Constellation it self (and so of the rest) have now so changed their Situation as to be mostly, or in great Part out of the respective Division; and in Process of Time be removed further and farther from it.

33.
Of the
twelve o-
ther Cir-
cles of the
Globe, viz.

Besides the Circles hitherto mentioned, there are usually drawn on the Surface of the celestial Globe, two other Circles; six whereof cross perpendicularly the *Ecliptick* between the Signs, the other six cross perpendi-

ly the *Equator* at every like (*viz.* Degrees) Distance, beginning to reckon from the first of *Aries*.

The six former are called Circles of *Latitude*, because that Arch of such a Circle, which is intercepted between any *Phenomenon* or Point of the Heavens and the *Ecliptick*, is the Measure of the said *Phenomenon*'s or Point's *Latitude*, *i. e.* Distance from the *Ecliptick* northward or southward. For the *Ecliptick* being the Circle in the Heavens of principal Regard, therefore, by it the Heavens are distinguished into two Hemispheres, one northern, the other southern.

34.
The six
Circles of
Latitude.

By the same Circles is also measured the *Longitude* of any *Phenomenon* or Point in the Heavens. For by the help of these Circles, any *Phenomenon* in the Heavens is referred to the *Ecliptick*, the said *Phenomenon* being understood to be in that Point of the *Ecliptick*, which is intersected by such Circle passing through the said *Phenomenon*; and the Arch of the *Ecliptick* between the first of *Aries* and the said Point of Intersection, is the Measure of the said *Phenomenon*'s *Longitude*,

35.
Which are
also Cir-
cles of
Longitude.

Longitude, or Distance from the
of *Aries* reckoned according to
Series of the Signs.

36.
And six
Circles of
Declinati-
on; among
which are
the two
Colures.

By the six other Circles, any *Phaenomenon* or Point in the Heavens referred in like manner to the *Equator*; and they are called Circles of *Declination*, because that Arch of such a Circle, which is intercepted between the said *Phaenomenon* and the *Equator*, is the Measure of its *Declination*, i. e. of its Distance from the *Equator*, northward or southward. Among these Circles, the two of which we have now spoken of, are to be noted. Note are the two (*) *Colures*; whereof crosses the two *Equinoctial* Points, and is therefore called the *Equinoctial Colure*; the other crosses the two *Solstitial* Points, and is therefore called the *Solstitial Colure*.

37. And thus we have described several Circles, and more remarkable Points of the celestial Globe. It remains to observe, that of all the mentioned Circles, these are the principal Circles of the Globe, usually reckoned Ten, and distinguished into six greater, and four lesser Circles.

(*) The Import and Reason of this Name well accounted for by any Writer of *Astronomy* know of.

reck

tioned the ten principal Circles of the Globe, viz. the *Horizon*, the *Meridian*, the *Equator*, the *Zodiack*, the *Ecliptick*, the two *Colures*, the two *Tropicks*, and the two *Polar* Circles. And these are distinguished into greater and lesser Circles; the six former being greater Circles, as being concentrical with the Globe it self, and dividing, each of them, the Globe into two Hemispheres or equal Parts; the four latter being lesser Circles, being not concentrical with the Globe, and so dividing, each of them, the Globe into two unequal Parts.

All the ten Circles last mentioned, are usually drawn on the terrestrial Globe; as also Circles crossing perpendicularly the *Equator* at every ten degrees; and other Circles running parallel to the *Equator* at every ten degrees. The former are called Circles of *Longitude*, the latter Circles of *Latitude*; forasmuch as these serve to shew the Longitude of Places, (i. e. their Distance from one of the said Circles taken at the first Meridian, and commonly called the first

38.
Of the terrestrial
Globe.

first *Meridian*, all these Circles Longitudes being also *Meridian* these serving to shew the Latitude Places, or their Distance from *Equator*. Besides these Circles mentioned, there are also usually drawn on the Surface of the terrestrial Globe, *Rumbs*, i. e. Circles crossing one another in some certain Points of the Globe, where there is a Vacancy, and representing the several Winds, or 32 Points of the Compass, set down also on the outer Rim of the *Horizon*, both of the celestial and terrestrial Globe.

the main Difference between the two Globes, is this, that on the surface of the celestial Globe are described the Constellations, and other fixed Stars in their due Situation on the Surface of the Terrestrial Globe are described the several Parts of Earth and Sea in their due Situation.

39.
An Observation concerning the Difference between the natural Appearance

Proceed we now to the Use of the celestial Globe, or to shew how the diurnal Phenomena of the celestial Lights are represented thereby. For the clearer Apprehension whereof seems requisite to observe, that

This Difference in general between the natural Appearances of the celestial Lights, and the artificial Representation of them by the Globe, viz. that the said celestial Lights do naturally appear to us as in the *Concave* or inner Surface of the Heavens, where they are represented upon the *Concave* or outer Surface of the celestial Globe. Wherefore to make the artificial Representation to answer more exactly to the natural Appearance, the Spectator must be conceived to be placed within the celestial Globe at its Center, and the Body of the Globe to be transparent to the Heavens, and in such a Position of the Eye, the celestial Phenomena on the Surface of the Globe will appear to the Eye in a concave face, as they do naturally; or else the Spectator is to be conceived as placed without the concave or inner face of the Heavens; and consequently as viewing from somewhere above the correspondent convex Surface of the Heavens; and upon such supposition, the celestial Phenomena would naturally appear to us in a convex

rances of the celestial Lights, and the artificial Representation of them upon the celestial Globe.

convex Surface, as they are represented by the Globe. Now we be placed upon the Convex, or out Surface of the Earth, and the several Parts of the Earth and Sea being presented likewise on the convex Surface of the terrestrial Globe; therefore there is an exact Agreement in this Particular, between the natural Position of the several Parts of Earth and Sea, and their artificial Representation by the terrestrial Globe, without the Help of any Fiction, as has been before observed requisite, to adjust the natural Appearance of the celestial Phenomena to their artificial Representation in the celestial Globe.

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C H A P. X.

the more useful Problems solved
by the Celestial Globe.

PROBLEM I.

find the Sun's Place in the
Ecliptick for any Day given,
g. Oct. 13. Old Style.

the Julian Calendar (placed next
to the Ecliptick) on the Horizon-
wooden Circle of the Globe find
Day given, to which adjoins the
Degree of the Ecliptick, where the
Sun is that Day. Thus to Oct. 13,
adjoins the first Degree of Scorpio, the
Place for that Day.

The Sun's Place being thus found by the Eclip-
tick on the Horizon, the same Degree of the Ecliptick
on the Surface of the Globe is to be taken, in order
to any of the following Problems.

P R O-

P R O B L E M II.

To find the Sun's Declination
any Time given, v. gr. Oct.
Old Style.

HAVING (by Problem 1.) found
Degree of the *Ecliptick*, where
in the Sun is at the Time given, bring
the said Degree to the graduated Edge
of the *Meridian* of the Globe;
Degrees of the said *Meridian*, inter-
cepted between the *Equator* and
Sun's Place, shews the Sun's Declin-
ation. Thus, Oct. 13. the Sun is in
the eleventh Degree of the South
Declination.

As in this, so in the following Problems
bringing any Point of the Globe to the *Meridian*
understood the bringing it to the graduated Edge
Meridian of the Globe, as being that which represents
the true *Meridian*.

In like manner, the *Latitude* of a Place
found upon the Terrestrial Globe, by bringing
Place to the graduated Edge of the *Meridian*,
reckoning the Degrees of the *Meridian* between
Place and the *Equator*. For as the Distance of
Point in the Heavens from the *Equator* is *Astronomical*
Declination, so the Distance of any Point on the
from the *Equator* is *Geographical Latitude*. What
requisite to be here known, forasmuch as about
the two following Problems respect indifferent
Latitudes and Places, the following Problems respect
only particular Places, the *Phænomena* relating
to varying according to the different *Latitudes*
Places.

PROBLEM III.

To rectify the Globe to any Latitude given.

MOVE the respective Pole (*viz.* the north Pole, if the Latitude be northern; the south Pole, if southern) above the *Horizon*, till there are so many Degrees of the *Meridian* between the said Pole and the *Horizon*, as answer to the Latitude given. Thus the north Pole being elevated 15 Degrees and an Half, the Globe is rectified for the Latitude of London.

[K]

P R O.

PROBLEM IV.

To find what Stars never rise
or never set in any Place
Latitude given.

THE Globe being (by Problem 3.) rectified to the Latitude given, such Stars as go not under the Horizon of the Globe, during whole Revolution, they never rise in the Latitude given. And such Stars as rise not above the Horizon of the Globe, during its whole revolution, they never set in the Latitude given. Thus the little Bear, the Dragon, Cephens, and Cassiopeia never set in the Latitude of London as also the great Bear, except the lower Part of its right Foot. On the other hand, the Peacock, the Indus, the Tucan, the Hydrus, the Dolphin, the Chamaleon, the southern Triangulum, the Apus, never rise in the Latitude of London.

P R

PROBLEM V.

To rectify the Globe, so, as that
it may be ready dully to repre-
sent the diurnal Phenomena,
at any Place and Time given,
v. gr. at London, Oct. 13.
Old Style.

THE Globe being rectified (by
Problem 3.) to the Latitude of
the Place given, bring the Sun's Place
in the *Ecliptick* for the Day given
found by Problem 1.) to the *Meri-
dian*, and make the Hour-Index to
point just to 12 on the Hour-Circle.
The Globe in such its Position will
actually represent the Position of the
Heavens, in Respect of the Place gi-
ven, at the *Hour* or 12 a Clock of
the Day given. And consequently
by the due Motion of the Globe,
may be represented the Position of
the Heavens, in Respect of the Place
[K 2] given,

given, at any other Part of the Day given.

Thus the north Pole being elevated $51\frac{1}{2}$ Degrees, which is the Latitude of *London*, and the first Degree of *Scorpio* (which is the Sun's Place, Oct. 13. Old Style,) being brought to the *Meridian*, the Globe will represent the Position of the Heavens in Respect of *London*, at Noon, Oct. 13. Old Style; that is, such Stars as are at or near the *Meridian* or *Horizon* (&c.) of the Globe, will then be respectively at or near the *Horizon* (&c.) of *London*. And consequently by the due Motion of the Globe may be represented the Position of the Heavens in Respect of *London*, at any other Hour of the same Day, and thereby may be found the Time of the Sun's Rising or Setting, of that Day, as is shewn in the following Problems. Only it must be remembered, that in Order to solve such Problems, as relate to the Time of any such *Phænomenon*, the *Hour-Index* must always be put exactly 12 on the *Hour-Circle*, before the Sun's Place be moved from the *Meridian*.

ur; and, also special Care must be
ken, that the Hour-Index moves
ly round with the Body of the
Globe.

In like manner, when the
Degree of the Ecliptick, wherein
the Sun is, being brought to the

side of the Horizon, the Hour-Index
will shew the Time of the Sun's

PROBLEM VI

*find the Time of the Sun's
Rising and Setting, and its
Amplitude, at any Place or
Time given.*

When the Sun is in the Equinoctial
Point, or after six in the Evening

THE Globe being (by Problem
5.) duly ordered and prepared,

the Globe, till the Degree of
Ecliptick, wherein the Sun is for

Day given, comes to the east Side
the Horizon; the Hour-Index will

shew upon the Hour-Circle the
Time of the Sun's Rising; and the

Degrees of the Horizon, intercepted
between the true east Point, and that

of the Horizon the Sun's Place
is to, shew its Morning Ampli-

[K 3]

tude,

itude, this being the Distance of the Point of the *Horizon* where the Sun rises, from the true east Point of the *Horizon*. In like manner, the Degree of the *Ecliptick*, wherein the Sun is, being brought to the west Side of the *Horizon*, the Hour-Circle will shew the Time of the Sun's Setting; and the Degrees of the *Horizon*, intercepted between the true west Point, and that Point of the *Horizon* which the Sun's Place is brought to, shew its Evening *Amplitude*, how far the Sun sets distant from the true west Point. Where it is to be noted, that the Sun sets so long before or after six in the Evening, as it rises after or before six in the Morning; and in like manner, the Sun sets so far distant (northward or southward, according to the respective Time of the Year) from the true west Point, as it rises from the true east Point.

Thus it will be found by the Globe that at *London*, *Oct.* 13. the Sun rises much about 7, and sets much about 5 a Clock; as also, that its *Amplitude* is 18 Degrees, the

rising so many Degrees to the South of the true east Point, and setting so many Degrees South of the west Point.

The Time of the Sun's Setting, being doubled, will give the Length of the Day; and the Time of the Sun's Rising, being doubled, will give the Length of the Night. Thus, *Q^d. 13.* the Day in the Latitude of *London*, is much about ten Hours long; and the Night much about 14 Hours long.

PROBLEM VII.

To find the Time of the Sun's Rising and Setting by its Ascensional Difference.

THAT Degree of the *Equator*, which, reckoned from the Beginning of *Aries*, rises or sets with

[K 4]

the

the Sun in a right Sphere, is called the Sun's *right Ascension*. And the Degree of the *Equator*, which, reckoned in like manner, rises or sets with the Sun in an oblique Sphere, is called the Sun's *oblique Ascension*. And the Difference between its right and oblique Ascension, is called its *ascensional Difference*.

The oblique Ascension of the Sun is found (the Globe being first rectified by *Problem 5.*) by bringing the Sun's Place to the east or west Side of the *Horizon*, and there noting what Degree of the *Equator* comes to the same Side of the *Horizon*, together with the Sun. The right Ascension of the Sun, is likewise found by putting the Globe into a right Sphere, and then noting what Degree of the *Equator* comes together with the Sun to the same Side of the *Horizon*. (or more readily and without changing the Globe from an oblique into a right Sphere, by) noting what Degree of the *Equator* comes up to the *Meridian*, together with the Sun (for the *Equator* always cuts the *Meridian* at right Angles, as it does the *Horizon*).

Horizon in a right Sphere; and consequently the same Degree of the Equator, that would come together in the Sun, or any Degree of the Tropick, to the Horizon in a right Sphere, will come, together with the same, to the Meridian in any oblique Sphere.) The quantities of the right and oblique Ascension being thus found, the ascensional Difference is found by subtracting the lesser out of the greater.

Now the right Ascension of the Sun being that Degree of the Equator which rises and sets with the Sun in a right Sphere, i. e. to such as is just under the celestial (or upon the terrestrial) Equator, to whom the Sun always rises at six, and sets at six, hence the ascensional Difference reduced into Time by reckoning one hour for every 15 Degrees, and so proportionably) shews how long the Sun rises and sets afore or after six, according to the Time of the

Thus

Thus the Sun's right Ascension *Or.* 13. is much about 208; and oblique Ascension on that Day Respect of London, is much about 223; and consequently, the seasonal Difference is 15, which amounts to one Hour in Time. Wherefore Time of the Year considered, Sun rises much about an Hour six, *i. e.* much about seven; and much about an Hour before six, much about five; agreeably to what was found by *Problem 6.*

PROBLEM VIII

To find the Sun's Altitude at Place and Time given.

THE Globe being rectified *Problem 5th*, the Degree of the Meridian reckoned from (the Side of) the Horizon to the Place, give the Sun's Meridian

e. Thus, *Oct. 13.* the *Meridian* Altitude of the Sun at *London*, will be about 17 Degrees.

The Altitude of the Sun is found by any other Time of the Day given, turning the Globe (rectified also *Problem 5.*) till the Hour-Index points to the Time assigned; and fastening the Quadrant of Altitude on to the *Meridian* at the Zenith; (i. e. at so many Degrees from the Equator, as is the Latitude of the Place given;) and bringing the said Quadrant so fastened to the Sun's Place in the *Ecliptick*: the Degrees intercepted on the Quadrant between the Sun's Place and the *Horizon*, shew the Sun's Altitude at the Time assigned.

Thus, *Oct. 13.* the Sun's Altitude at nine in the Morning, will be about 17 Degrees in Respect of the *Horizon* of *London*. And the same will be its Altitude at three in the Afternoon. For it is to be noted, that at Times equally distant (before and after) from 12, the Sun's Altitude is also equal.

PROBLEM IX.

To represent the Face or Appearance of the Heavens, shew the Situation of the Stars, at any Time of Night, in Respect of any Place and Night given.

THE Globe being rectified Problem 5th, and (by Needle) set so, as that its cardinal Points answer the cardinal Points of the Compass, turn the Globe till the Hour-Index Points to the Time of the Night assigned. Such Stars appear at or near the Meridian Horizon (and so of any intermediate Point) of the Globe, will appear likewise at or near the Meridian Horizon of the Place given; (and of any intermediate Point in the Heavens.)

Thus, Oct. 13. at Ten at Night, the glorious Constellation *Orion* will appear on the east Side of the Horizon of London; the Star *Rigel* in the Knee of *Orion* being just at the Horizon; the three Stars in the same Constellation, called by our common Name the *Yard*, a little above the Horizon. About twenty Degrees (on the vertical Circle) above the uppermost of these appears the bright Star *Taurus*, called *Aldebaran*, and the *Eye*; and somewhat above this the same Constellation, the celebrated Stars called the *Hyades*, and *Pleiades*, these being in the Back, and in the Forehead of *Taurus*. Just after the Meridian southward appears the Star called *Andromeda's* Head, and at or near the Meridian the Constellations of *Cassiopea*, *Cepheus*, *Perseus*, &c. Between the Meridian and the west Side of the Horizon appears the Constellations of the *Swan*, *Cygnus*, &c. And at or near the west Side of the Horizon, the Constellations of *Antinous*, *Serpentarius*, the *Worm's* Head, &c.

Hence

Hence it is obvious, that this blem is of good Use to find out know the several Constellations, the more remarkable Stars in Constellation.

PROBLEM X.

To find the Hour of the Night the Altitude of any Star being given, or first found some Instrument for that pose.

THE Globe being rectified according to Problem 3. and Quadrant of Altitude duly fixed to the Meridian, move the Globe till the said Quadrant cross the given Altitude; then the Index will shew the Hour of Night.

Thus, *Oct. 13.* the Altitude of *Al-
ran*, or the Bull's Eye is found
be 27 Degrees, 30 Minutes. Where-
e moving the Globe till the Qua-
nt of Altitude crosses the said Star
27 $\frac{1}{2}$ Degrees of Altitude, the Hour-
ex will then Point to Ten at
ght.

Here it is obvious, that if the Star
in the *Meridian*, then there is
casion only to turn the Globe
stified by *Problem 5.*) tilt the said
comes to the *Meridian* of the
be: for then the Hour-Index will
w the Hour.

P R O-

PROBLEM XI

To find the Beginning of
(Crepusculum, i. e.) Twilight
or the Time of Day-break
any proper Time of the Year

THE Globe being (by Prob
5.) rectified, elevate that
gree of the *Ecliptick*, which is
metrically opposite to the Sun's Place
at the Time given, 18 Degrees above
the west Side of the *Horizon*;
the Hour-Index will shew the Time
sought. Thus, Oct. 13. Day break
or the Twilight begins about a Quarter
before five, at *London*.

The Reason of elevating the
gree of the *Ecliptick*, diametrically
opposite to the Sun's Place, 18
degrees above the west Side of the
Horizon, is this; because, thereby
Degree of the *Ecliptick* wherein
Sun is at the Time given, is depressed
18 Degrees below the east Side

Horizon. At which Depression it is observed by *Astronomers*, that the morning Twilight begins, as also, the evening Twilight ends at like Depression of the Sun, under west Side of the *Horizon*. Whence is obvious, that the Beginning of morning Twilight being found, is obvious to know, when the evening Twilight ends; this ending is much after six in the Evening, as begins before six in the Morning, *Or.* 13. the evening Twilight ends about a Quarter after seven, at any Place in the same Latitude.

It is to be further noted, that the morning Twilight Beginning, when the Sun is 18 Degrees below the east Side of the *Horizon*; and the evening Twilight ending, when the Sun is 18 Degrees below the west Side of the *Horizon*, it thence follows, that, during that Part of the Year, wherein the Sun's Depression is never so much as 18 Degrees, there is no Beginning of morning Twilight, or Ending of evening Twilight, but one continued Twilight from Sun setting

[L]

to

to Sun-rising. Now that Part of Year, wherein there is such a continued Twilight in the Latitude of London, is while the Sun is past from about the fifth Degree of *Cancer*, to the twentieth of *Cancer*, from about the 15th of *May*, about the 7th of *July*. For during this Space, the Sun is never depressed 18 Degrees below the *Horizon*.

PROBLEM XII.

To find the Longitude and Latitude of any Star given.

LAY one End of the Quadrant upon the proper Altitude upon the proper of the *Ecliptick*, (viz. if the Star is in the northern Hemisphere of Heavens, upon the north Pole; otherwise, on the south Pole,) the graduated Edge thereof upon the Center of the Star; so will the Quadrant cut the *Ecliptick* in the Longitude

itude, (i. e. its Distance from the first of Aries.) and the Degrees of the Arc intercepted at the same Point between the Star and the Ecliptick will give its Latitude, this being no other than the Star's Distance from the Ecliptick. Thus the Longitude of the Star called *Lucida Lyrae*, will be found to be 283 Degrees, its Latitude about 60 Degrees Northwards.

It is obvious, that the Sun, being always in the Ecliptick, never hath Latitude; and its Longitude is found without any more ado, than by computing the Number of the Days it is in, from the first of March. Thus, Oct. 13. the Sun is in the 190th Degree of Longitude, that is, the Distance or Number of the Degrees of *Scorpio*, where the Sun is, from the first of *Aries*.

There are some other Problems, which may be solved by the Globe; but they being of little Use are here omitted. And so we are come to the End of this Astronomical Treatise,

[L 2] wherein

wherein are contained such
 lars, as seem more useful to be
 by Young Students, especially
 Gentlemen, at their first Institution
 Astronomy.

F I N I S

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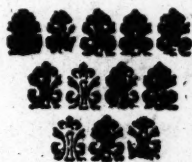
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THE
PREFACE.

THE Art of Chronology has so close a Dependence upon Astronomy, that it is not usual for Writers of Astronomical Treatises to contain therein a great deal of what more properly belongs to Chronology; and which therefore I have here laid together, with the other most

A 2 useful

The Preface.

*useful and easy Elements
Chronology, in a dist
Treatise from my Astron
my. But the Design
of the One and the O
being the same, as there
I have given my Astro
mical Treatise the Title
The Young Gentleman
Astronomy, so I have
ven this my Chronolog
Treatise the Title of
Young Gentleman's Ch
nology: nothing being b
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lates to the common (C
or Ecclesiastical) Comp
tion of Time, and to
two Celebrated Æra's of
Olympiads, and the Bu*

The Preface.

ding of Rome, the former chiefly used by Greek Historians, the latter by Roman.

The

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C H A P. VIII.

THE
Young Gentleman's
CHRONOLOGY, &c.

CHAP. I.

Day; and the Parts of Time
arising from a Day by Division,
viz. Hours and Minutes.

Y (*) *Chronology* is understood
the Art or Skill of adjusting
Things past to their proper
Times.

Hence Chronological Institutions
consist of the Explication of, the seve-

I.
Chronology, what.

2.
Distin-
guish'd into
two Parts:

The Word *Chronology* denotes literally in the
Language a *Discourse* or *Account of Time*, being
composed of χρόνος *Time*, and λόγος *a Discourse*
account.

B **ral**

ral *Parts*, into which Time in general is divided; and of the several *Classes*, by which particular Times are distinguished one from another.

3.
All other
Parts of
Time arise
from a
Day, either
by Divisi-
on, or Col-
lection.

The several *Parts* of Time are, *Minutes, Hours, Days, Weeks, Months, and Years*. Amongst which we first speak of a *Day*, because from it arise the other *Parts* of Time, considered as they are applied to common Use. For as *Hours* and *Minutes* arise from a *Day* by Division and Subdivision; so *Weeks, Months, and Years* arise from a *Day* by Collection, reckoning such or such a Number of *Days* together.

4.
A Day,
what, pri-
marily and
properly.

By a *Day* then, according to its primary (+) Intention of the Name denoted the Time of Light; and in this Sense it is opposed to Night, the Time of Darkness. And the Sun being made to (||) rule the *Day*, hence a *Day*, according to the primary Intention of the Name, seems most properly and naturally to be determined

(+) God called the Light Day; and the Darkness called Night, Gen. 1. 5.

(||) God made two great Lights; the greater Light to rule the Day, Gen. 1. 16.

the Sun's Rising and Setting, and to be most properly and naturally defined, the Stay of the Sun above the Horizon, or the Time between the Sun's Rising and Setting. Agreedly whereunto, Night is the Stay of the Sun below the Horizon, or the Time between the Sun's Setting and Rising.

But the Word *Day* is frequently taken in a larger Sense, so as to comprehend also the Night, and to denote a whole Revolution of the Sun round the Earth. This Sort of Day is most properly denoted by the Greek Word (*)

Nuchthemeron.

The *Nuchthemeron* may be reckoned, either from Sun-setting to Sun-rising, as did the Jews and Athenians, and as the Italians still do; or from Sun-rising to Sun-rising, as did the Babylonians; or from Mid-day to Mid-day, as do the Generality of

5.
Another
Acceptation
of a
Day for a
Nuchthemeron, or
24 Hours.

6.
Different
ways of
computing
the Nuchthemeron.

(*) It is a Compound of *nu* a Night, and *themeron* a Day. The two-fold Acceptation of the Word *Day*, distinguished usually by the Names of a *Natural* and *Artificial* Day. But some calling that a natural Day, which others call an Artificial, hence arises great Confusion; to avoid which I judge it best, wholly to omit this Distinction.

Astronomers, and likewise the *Arabs* or lastly, from Mid-night to Mid-night, as did the old *Egyptians*, and *We* of this Island, together with the *French*, *Germans*, and other *Europeans* still do.

7.
Of an
Hour.

Proceed we now to the Part of Time, called an *Hour*. And here is principally denoted the 24th Part of a *Nuchthemeron*. Now a *Nuchthemeron* being the Space of an entire Revolution of the Sun about the Earth during which the Equator makes an (+) entire Revolution, hence

(+) In strictness the Equator makes somewhat more than one Revolution, during a *Nuchthemeron*; viz. much more as answers to the Sun's apparent proper Motion in the Ecliptick during the said Space of Time. Now this Overplus being various, viz. 57 Minutes at the Sun's Apogee, and 61 Minutes in its Perigee, hence Astronomers take the Mean between the two fore-mentioned Numbers for a standing Measure through the whole Year, and so compute that to every *Nuchthemeron* there answers $59^{\circ} 8''$, and almost $20''$, over above a Revolution (or the 360 Degrees) of the Equator. But now the Difference between the Sun's Revolution (or a *Nuchthemeron*) and the Equator's, which is greatest, being but 61 Minutes or a little more than one Degree, which answers but to a little more than one Minute in Time, hence it may be passed over unregarded in common Use; and the Hour here spoken of may be well enough esteemed to answer just to one Degree of the Equator.

CON

Of Hours.

3

comes to pass, that as the whole Circle or all the 366 Degrees of the Equator answer to a whole *Nachtbemer*, so a 24th Part or 15 Degrees of the Equator answer to a 24th Part of *Nachtbemer*, or such an Hour. And because these Hours are all thus equally measured by 15 Degrees of the Equator, hence they are all looked on as *Equal* one to another at all times.

But the *Jews, Greeks, and Romans* anciently divide (not the *Nachtbemer* into 24 equal Hours, but) the Day, whether longer or shorter, into 24 Hours; and so likewise the Night. Hence it is obvious, that their Hours are *Unequal* one to another, except only at the two (||) Equinoxes; when the Day and Night being Equal, their Hours would likewise be Equal, and the same as to Extent with our Hours, though not as to Denomination.

8.
Of Temporary or unequal Hours.

Hence the equal Hours used by us are sometimes *Equinoctial* Hours; and the unequal Hours used by the *Jews, &c.* are stiled *Temporary* Hours, from their varying in Length according to the other various of the Year.

B 3

For

9.
How the
unequal
Hours an-
swer to our
common
equal
Hours.
Which Ob-
servation
is of use
for under-
standing
the Bible-
History.

For they always reckoning the first Hour of the Day from the Sun Rising, which at the Equinoxes answers exactly to our six a Clock in Morning, it follows, that their first Hour of the Day must answer at the Equinoxes to our seven a Clock in Morning; and consequently their third Hour to our nine a Clock in Morning; their sixth to our twelve a Clock at Noon; their ninth to our three a Clock in the Afternoon, &c. And although there is not so exact Correspondence between the Hours used by them and us, at other Times of the Year, yet the fore-mentioned Observation is of good Use for a better Understanding the several Hours of the Day mentioned in the Sacred History.

10.
As is also
the Jewish
Division
of the
Night into
Watches,
&c.

Upon the like Account it is not to be here omitted, that the Jews divided the Night (not only into twelve Hours, as is afore observed; but also into four Quarters, called *Watches*, each Watch containing three of the Night-hours. These Watches were distinguished, either by their number or Order, whence we expressly read

Of Minutes.

8

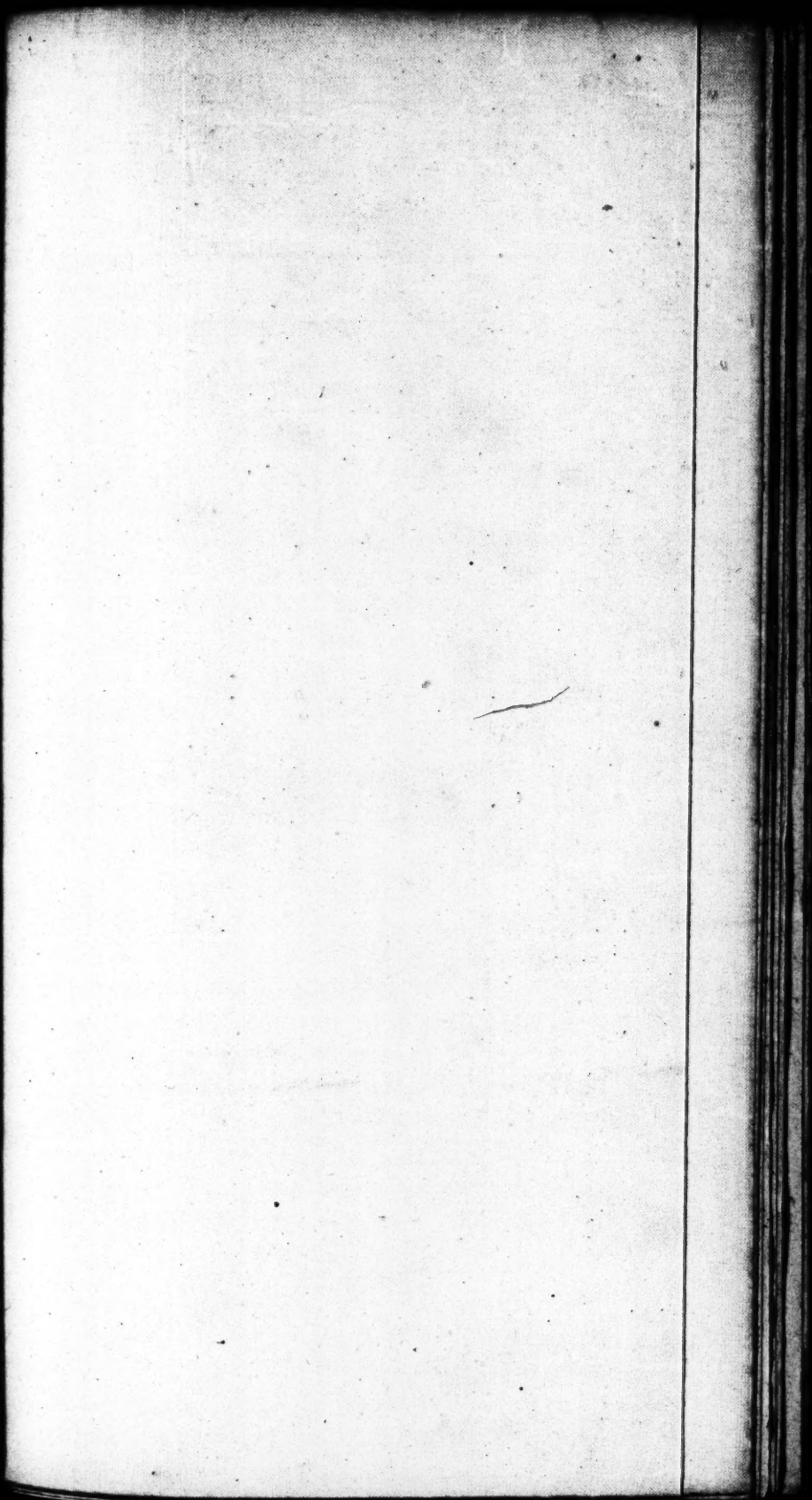
the Sacred History of the (*) *Second*,
Third, and (†) *Fourth* Watch; or by
 some other Denomination. Thus the
 first Watch is otherwise styled the (||) *Head*
 or *Beginning of the Watches*; the
 second, the (*) *Middle* Watch, be-
 cause it lasted till Mid-night; and the
 fourth, the (†) *Morning* Watch. A-
 gain, the First was termed (||) the
Opening; the Second, *Mid-night*; the
 third, the *Cock-crowing*; the Fourth,
 the *Dawning*.

The common Division of an Hour
 into *Quarters*. But Astronomers,
 and such as are more accurate in ac-
 counting Time, divide an Hour into
 sixty Parts, called *Minutes*; and a
 Minute again into sixty Parts, called
Seconds, as being Minutes of Minutes,
 and so secondary Minutes. And here
 is to be observed, that the Word
Minute is taken in a double Sense, ei-
 ther to denote the sixtieth Part of an
 Hour, which therefore is peculiarly
 styled an *Horary* Minute; or else to
 denote the sixtieth Part of a Degree,

II.
 of Mi-
 nutes, and
 Seconds;
 and the
 Difference
 between
 Horary
 and Gra-
 duary Mi-
 nutes.

(*) Luk. 12. 38. (†) Matt. 14. 25. (||) Lam.
 19. (*) Judg. 7. 19. (†) Exod. 14. 24. (||)
 Mark 13. 35.

which therefore may be distinguished by the Name of a *Graduary Minute*. And this *Graduary Minute* is subdivided by Astronomers into sixty *Seconds*, and also each *Second* into sixty *Thirds*, and each *Third* into sixty *Fourths*, &c. whereas it is usual to subdivide an *Horary Minute* only into *Seconds*. Now as 15 Degrees of the Equator answer to one Hour or sixty *Horary Minutes*, so one Degree of the Equator or sixty *Graduary Minutes* answer to four *Horary Minutes*; and so one *Horary Minute* to fifteen *Graduary Minutes*. And thus much for the several *Parts of Time*, which arise from *Day by Division, and Subdivision*.



IX	X	IX	XI	X	IX	II	I	II	III
----	---	----	----	---	----	----	---	----	-----

C H A P. II.

the several Parts of Time, which arise from a Day by Collection ; viz. Weeks, Months, and Years.

Among the several Parts of Time, which arise from a Day by Collection, it is proper to speak first of a Week, not only as denoting the smallest Collection of Days, namely, more than seven ; but also as being the most Antient Collection, as we learn from the Sacred History, whereby we are taught that it was instituted presently after the Creation, in Memory of God's creating the world in six Days, and resting on the seventh from all his Works, which he made.

1.
Of a Week properly so called.

The seven Days of the Week are commonly distinguished by the Name of the Planets, accounted also just according to the Vulgar System, placed in this Order from the highest to the Lowest, viz. Saturn,

2.
The seven Days of the Week whence take their common Denominations.

Jupiter,

Jupiter, Mars, the Sun, Venus, Mercury, and the Moon. Now the Astronomers supposing the fore-mentioned Planets to preside or rule over the several Hours of the *Nuchthemeron* according to their Order above-mentioned, hence denominate each Day of the Week from that Planet, which is supposed to preside over the first Hour of the *Nuchthemeron*. Whence it comes to pass, that the Days are denominated from the Planets according to the common Method. For assigning the first Hour of *Saturday* to *Saturn*, the second will fall to *Jupiter*, the third to *Mars*, the fourth to the *Sun*, the fifth to *Venus*, the sixth to *Mercury* and the seventh to the *Moon*. Also the eighth Hour will fall to *Saturn* again, and also the fifteenth and twenty-second of the said *Nuchthemeron*; and consequently, the twenty-third Hour will fall to *Jupiter*, the twenty-fourth to *Mars*. By which means the first Hour of the next *Nuchthemeron* will fall to the *Sun*, and the first Hour of the next to the *Moon*, the next to *Mars*, of the next to *Mercury*, of the next to *Jupiter*, of the next to *Venus*; and of the next to

Of Weeks.

11

again, and so through the next Week as afore. Hence the Days of the Week came to be distinguished in their Order by the Latin Names of *Saturni, Solis, Lune, Martis, Mercurii, Jovis, and Veneris*; and so among us by the Names of *Saturday, Sunday, Monday, Tuesday, Wednesday, Thursday, and Friday*. For as *Saturday, Sunday, and Monday*, plainly denote the Day of *Saturn*, the *Sun*, and the *Moon*; so *Tuesday, Wednesday, Thursday, and Friday*, denote the Day of *Tuisc*, *Woden, Thor, and Friga*; which are the Saxon Names respectively answering to *Mars, Mercury, Jupiter, and Venus*.

It is also not to be omitted, that, because the *Easter Week* was formerly deemed the First or Principal Week of the Year; and each Day thereof was a *Feria* or *Holy-Day*; hence the several Days of the Week were distinguished in their respective Order, among the Primitive Christians, by the Names of *feria Prima, Secunda, &c.* i. e. the *First, Second (&c.) Holy-Day: Sunday*, or the *feria Prima* being otherwise stiled by them *the Lord's Day*,

3.
The Days
of the Week
how deno-
minated by
the Anti-
ent Chri-
stians.

Day, as being the Day of our Lord's Resurrection.

4.
A Week
sometimes
taken to
denote the
Space of
seven
Years.

Hitherto we have spoken of a Week in its common Acceptation, as it notes a *Week of Days*, or *seven Days*. But it is not wholly to be past that as the Original or *Hebrew Word* which we render a Week, does usually denote only in general a *Collection of Seven*, and therefore may be applied to Years as well as Days, (the same holds as to the correspondent (*) *Greek and Latin Words*), it is actually used in (†) some Places of the Sacred History to denote, *seven Days*, but *seven Years*. In Conformity to the Use of the Original Word, our *English Word Week* is used in the said Places of Sacred Scripture to denote, not a *Week of Days*, but a *Week of Years*, or a Collection of seven Years.

4.
A Synodi-
cal Month,
primarily
called a
Month.

Proceed we next to speak of *Months*, which, as they are of various Sorts, so are called by this one common Name, not by mere Chance, or without any Reason, but by Reason

(*) Hebdomas and Seprimana. (†) So Dr. 28-27

all agreeing in some Relation to Month primarily so called. Now the (II) *Hebrew* Word, to which our Word *Month* answers, does literally report the Time from one *New Moon* to another; and so does properly denote *Synodical Month*. And forasmuch this Sort of Month is most distinguishable by our Sense, and so most obvious and proper to be used as a Measure of Time in the common Affairs of Life; hence it is more than probable, that, as our Word *Month* evidently derived from the Word *moon*, so it was primarily intended to denote likewise the Time from one *New Moon* to another, or a *Synodical Month*. For it is more than probable, that this Word in our Language (and of the correspondent Words in all other Languages) was first used to denote that Sort of Month, which was observed as a Measure of Time. Now it is not reasonably to be

The *Hebrew* Word *Chodesh* (is derived from a Word which signifies to *Renew*, and accordingly) primarily denote the *New Moon*, or the *Day of New Moon*; and thence it is secondarily taken to denote a *Month*, being the Space from one *New Moon* to another.

doubted,

doubted; but the Synodical Month was first used as a Measure of Time forasmuch as it is obvious to the Sense, even of the Vulgar and illiterate Persons.

5.
*The Periodical
Month why
called a
Month.*

As for the *Periodical Month*, or Time wherein the Moon goes round her Orbit, this could not be determined without some Observation and Study; and therefore no doubt was not taken Notice of, till some Time after the Synodical Month was known. And consequently it is not to be doubted, but the name *Month* was applied to the Time of the Moon's Periodical Course, not primarily, secondarily, or after it had for some Time been applied to the Moon's Synodical Course. And the Reason of imposing the same Name upon the Time of that, as had been imposed afore upon the Time of this, was, because both Times agree in the general sense, viz. as they relate to the Course of the Moon, and so may both from the Moon be called *Months*.

6.
*Of the different
Lengths of
the Syno-*

It has been afore (in the Astronomical Treatise, Chap. 4. Sect. 2.) observed, that the Periodical Month consists of 27 Days and $7\frac{1}{4}$ Hours.

Of Months.

19

the Synodical Month of 29 Days, 12 $\frac{1}{2}$ Hours. And the Reason of this Difference has been there accounted for.

It is here to be further noted, that, ^{7.}
 cause during (either a Synodical or ^{A Solar}
 (odical) Month of the Moon, the ^{Month,}
 passes well-nigh through a whole ^{what, and}
 of the Ecliptick; hence the Time ^{why called}
 the Sun's passing quite through a ^{a Month.}
 is called a Solar Month, as nearly
 answering to the Space of a Lunar
 month, especially the Synodical Month;
 as this Sort of Lunar Month is a
 little above 29 $\frac{1}{2}$ Days, so the fore-
 mentioned Solar Month is almost 30
 Days; and consequently the Differ-
 ence between them is but about one
 Day.

But now because the fore-mentioned ^{8.}
 Solar and Lunar Months do not ^{Civil}
 consist just of whole Days, but of ^{Months,}
 the odd Hours and Minutes over, ^{what, and}
 which cannot be considered in the ^{why called}
 common Account of Time; therefore ^{Months.}
 a certain Number of just whole
 Days are made use of instead of the
 fore-mentioned Astronomical Months;
 however are called likewise Months,
 inasmuch as they come as near as can
 be

be to the said *Astronomical* Month from which they are distinguished the Name of *Civil* Months, as being adapted to Civil or Common Use.

9.
A Month
of Weeks,
what.

Thus in the first Place, what is commonly called a Month among is made to consist just of twenty-eight whole Days, and so just of four whole Weeks; whence it is peculiarly styled *the Month of Weeks*. It is obvious that in Order to render the Computation of Time from Weeks to Months more easy, and so more fit for common Use, it was necessary that a Month should consist just of some certain Number of whole Weeks: which being thus necessary, four whole Weeks were made Choice for that Number, which should constitute a Month; because this Number comes nearer than any other Number of Weeks, to the several *Astronomical* Months afore-mentioned.

10.
The Civil
Synodical
Month,
what.

The *Astronomical* Synodical Month is adapted to Civil or Common Use by making the Civil Synodical Month to consist alternately of (*) twenty

(*) A Civil Synodical Month consisting of thirty Days, is called *Plenus*, i. e. a Full Month; and a Synodical Month consisting but of twenty-nine Days is called *Cavus*, i. e. an *Hollow* or *Defective* Month.

Of Months.

17

ine and thirty whole Days; for $29 \times 2 = 58$, that is, two Civil Synodical Months are equal to two Astronomical Synodical Months, admitting in both the odd Minutes. and consequently, according to this method, the New Moon will keep to the first Day of every such Civil Month for a long Time together, when once adjusted thereto. This is the Month in Civil or Common Use among the *Jews, Greeks, and Romans*, till the Time of *Julius Caesar*, and is still so among the *Turks*.

In like manner, the Astronomical Year Month may be adapted to common Use, by making the Civil Solar Months to consist alternately of thirty and thirty-one Days, excepting one Month of the twelve, which should consist of thirty Days every four Years; in other three Years it must consist of twenty-nine Days. This is illustrated by the adjoining Scheme or Table of the Solar Months.

II.
The Solar Months might be uniformly adapted to Civil or Common Use.

C

Months.

Months.	Days.	Months.	Days.	Months.
March	31	Quintilis	31	November
April	30	Sextilis	30	December
May	31	September	31	January
June	30	October	30	February

And every fourth Year

For according to this regular and form Method, there will be 365 Days in the twelve Solar Months for the Years together, and every fourth Year 366 Days, just as it is now.

12.
The Solar
Months
how came
to be insti-
tuted, as
in Use a-
mong us.

It is evident then, that the Solar Months might be thus uniformly constituted. And indeed they were so constituted in the main, at first by *Julius Caesar*, who brought the Solar Months into common Use among the *Romans*; whereas they used aforetime the Civil Lunar Month, as was observed when we were speaking of the said Lunar Month. The Alteration was made afterwards, when the fifth Month, which had aforetime been called from its Rank, *Quintilis*, was new named *Julius* in Honour of the Emperor of that Name; so the sixth Month, which had aforetime been called

(†) Sect. 10th of this Chapter.

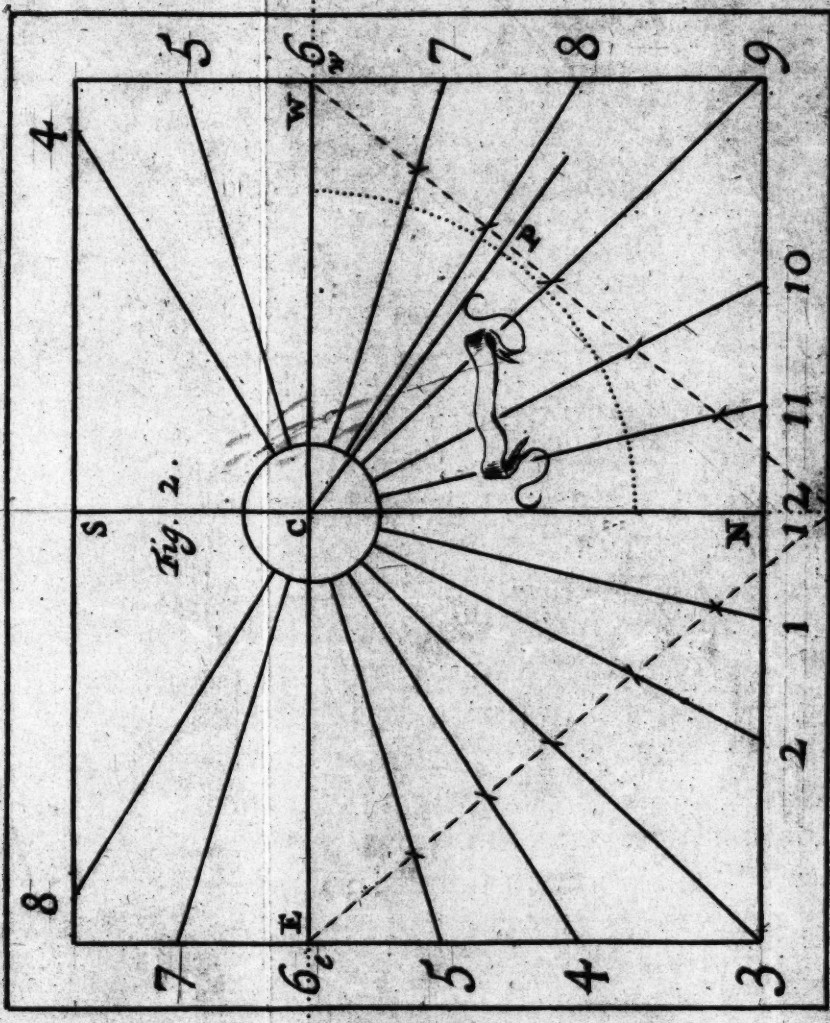
*Place this
facing p. 18.*

8

4

Place this
facing p. 18.

Pl. 2



An HORIZONTAL Dial drawn by y help of Dialling Scales.

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from its Rank, *Septilis*, was new named *Augustus* in Memory likewise of the Emperor of the same Name; and not only so, but (whereas this Month consisted afore but of thirty Days, and so was a Day shorter than the foregoing Month of *July*;) there was a Day more added to it, that to the Honour paid to *Augustus* might not seem to fall short of the Honour paid to *Julius*, even in this Punctilio. Now this Alteration being made as to the Month of *August*, it (according to the alternate Method at first instituted, and still preserved in the following Months) made an Alteration in all the following Months, except *January*, which upon this Alteration should have had but thirty Days according to the alternate Method primarily instituted. But this Month being so named in Honour of *Janus*, esteemed by the Romans, the God of Time, on the Consideration that it seemed proper to lengthen the Month of *August* a Day, it might seem not proper to lessen the Month of *January* by a Day; but rather to continue it still thirty-one Days long, and to make *February*, which afore was twenty-

nine, and every fourth Year thirty-eight, and every fourth Year twenty-nine Days long. And the Solar Months came to stand, as do now in our *Calendar*, (which they are called the *Calendar Months* in reference to the Names and Number of Days assigned to each) down in short in the following Table.

Months.	Days.	Months.	Days.	Months.
March	31	July	31	November
April	30	August	31	December
May	31	September	30	January
June	30	October	31	February

But every fourth Year

By comparing this and the foregoing Table, will be illustrated whatever has been here said, either concerning the first Institution of the Solar Months among the Romans by *Julius Caesar*; or concerning the Changes that have been since introduced; also it will appear, that the Number of Days, contained in twelve Solar Months taken together hath been all along the same, 365 Days, and every fourth Year Days. The former of which Sun

Dial. Plate 2.

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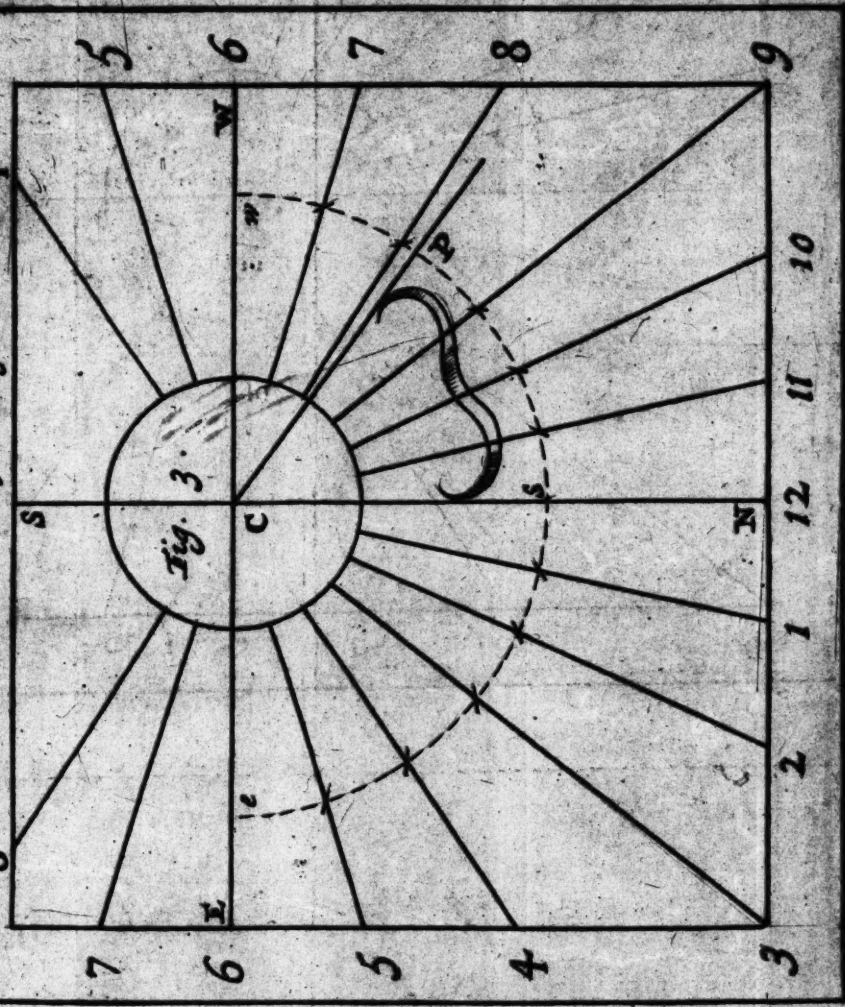
pag. 20.

Page 3

8 Horizontal Dial drawn by Dialling Tables . 4

Place this facing
 pag. 20.
 Part 2.

8 Horizontal Dial drawn by Dialling Tables 4



A Direct South Dial drawn by y^e help of y^e Equinoctial Dial.

I

9	10	11	12	1	2	3
---	----	----	----	---	---	---

the Time, wherein the Sun seems to pass through the twelve Signs, (†) omitting the odd Hours and Minutes; and the latter Sum is the Time, wherein the Sun seems to pass through the twelve Signs, adding thereto the odd Hours and Minutes which were omitted the three foregoing Years, and so many Minutes more as make the said odd Hours and Minutes equal to a whole Day in four Years.

Now as these twelve Solar or Calendar Months make up the Civil Solar Year in use among us, (in which sense it is, that a *Twelve-Month* is used by us as an Equivalent Term to a Year) so what has been said concerning the Sums of 365 and 366 Days being contained in the twelve Calendar Months taken together, will be more particularly explained, when we come presently to speak of the Civil Year in use among us; after that we have made some short Observations concerning the Year in gene-

13.

A Twelve-Month how Equivalent to a Year,

(†) See Sect. 16. of this Chapter.

14.
A Year,
what, in
general.
It is pro-
perly taken
to denote a
Solar Year.

By a (†) Year then (the only Part of Time remaining to be treated of) is denoted in general a Revolution of a Celestial Light round the Heaven by (what is esteemed) its proper Motion. Thus an entire (apparent) Revolution of the fixed Stars is stiled a Great Year; and the Time, wherein Saturn, Jupiter, and Mars, go round their Orbits, is respectively stiled a Year of Saturn, Jupiter, and Mars; and accordingly the Time of the Moons going round her Orbit, commonly called her Periodical Motion, is sometime stiled her Year. But the Year is principally and properly denoted the Time, wherein the Sun appears to move round the Ecliptic, which is 365 Days, 5 Hours, and very near 49 Minutes.

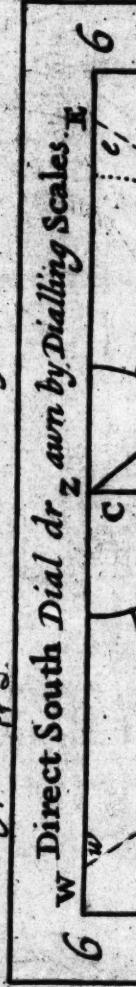
15.
A Lunar
Year,
what.

Now because during the Time of one Solar Year, there are twelve Nodical Months; hence twelve Sy-

(†) As the Latin Word *Annus* primarily denotes a Circle (whence *Annulus* signifies a Ring) and is taken to denote a Year, as being a Circle of Time, which being once gone round is begun again; the Greek Word *ἐνιαυτός*, and the Hebrew Word *שנה* is of the like Importance.

Place this facing p. 22. p. 2.

Dial. Plate 3.



4 p. 23

PART 2.

10	11	12	1	2
----	----	----	---	---

al Months constitute (what is cal-
ed) a *Lunar Year*; which therefore
ists of 354 Days, 8 Hours, and a
le more than 48 Minutes. So that
the exact Difference between the A-
stronomical Solar and Lunar Year is
Days, 21 Hours, and 1 Minute.

But whereas the Hours and Minutes
bove the whole Days of a Solar
ear, can't be taken Notice of in Ci-
il or Common Use; therefore the
vil Solar Year in use among us, is
ade to consist only of 365 Days for
ree Years together, and every fourth
ear of 366 Days. Namely, whereas
an Astronomical Solar Year there
above the whole Days, 5 Hours,
very near 49 $\frac{1}{2}$ Minutes; there
added every Year about 11 Mi-
utes, to make up this just six Hours;
these six Hours amount just to a
ole Day in four Years.

Each of the three Years consisting
y of 365 Days, is called a *Common*
ear; and every fourth Year consist-
g of 366 Days, is called a *Bessextile*
Leap-Year. The Reason of its be-
g called *Bessextile* is, because the
ay arising in four Years out of the
Hours afore-mentioned, is this

16.

*The Astro-
nomical
Solar Year,
how adap-
ted to Ci-
vil or Com-
mon Use,*

17.

*A Bessex-
tile or
Leap-
Year, why
so call'd;*

Year *intercalated*, i. e. inserted in the Calendar, by reckoning (according to the Roman Way, *bis sextæ Kal. Martii*, i. e. by reckoning) *twice the sixth Day* before the Calends of *March*, which answers to our twentieth of *February*. But although we took our Civil Solar Year from the Romans, yet we do not imitate them in this particular, but instead of reckoning *February* twenty-four twice, we reckon this Year twenty-nine Days of *February*, whereas in common Years we reckon but twenty-eight. But although we reckon not *February* twenty-four twice, yet we reckon twice the Calendar Letter always belonging to *February* twenty-four; namely *f*. And by this means, that which was the *Sunday* Letter from *January* the first of *February* twenty-fourth, will be so no longer, but the Letter next before in the Order of the Alphabet, will be the *Sunday* Letter for the remaining Part of the Year. From which Difference or Change from one *Sunday* Letter to another, this Year came to have the Name of *Leap Year* amongst us.

Of Years.

25

It has been afore observed, that the Astronomical or true Solar Year does consist of 365 Days, 5 Hours, 49 Minutes. Whereas to adapt it to Civil Use, the Solar Year is conceived to consist of 365 Days, and just six Hours; (which six Hours in four Years make up just another whole Day;) so that the Civil Solar Year is about eleven Minutes longer than the true Solar Year. Hence it comes to pass, that the Seasons, or (which comes to the same) the Equinoxes and Solstices, depending on the true Solar Year, do not keep always to the same Time or Part of our Civil or Common Year, but vary every Year about eleven Minutes, (*viz.* 10', and 48",) and consequently about a whole Day in 133 Years. Wherefore from A. D. 325, when the famous *Nicene Council* was held, to A. D. 1582, wherein Pope Gregory the XIII. reformed the Calendar, there was found to have arose a Variation of ten Days; the vernal Equinox, which at the Time of the *Nicene Council* fell about the first of March, in A. D. 1582, being found to fall on March the 11th. Hereupon the fore-mentioned Pope, intending

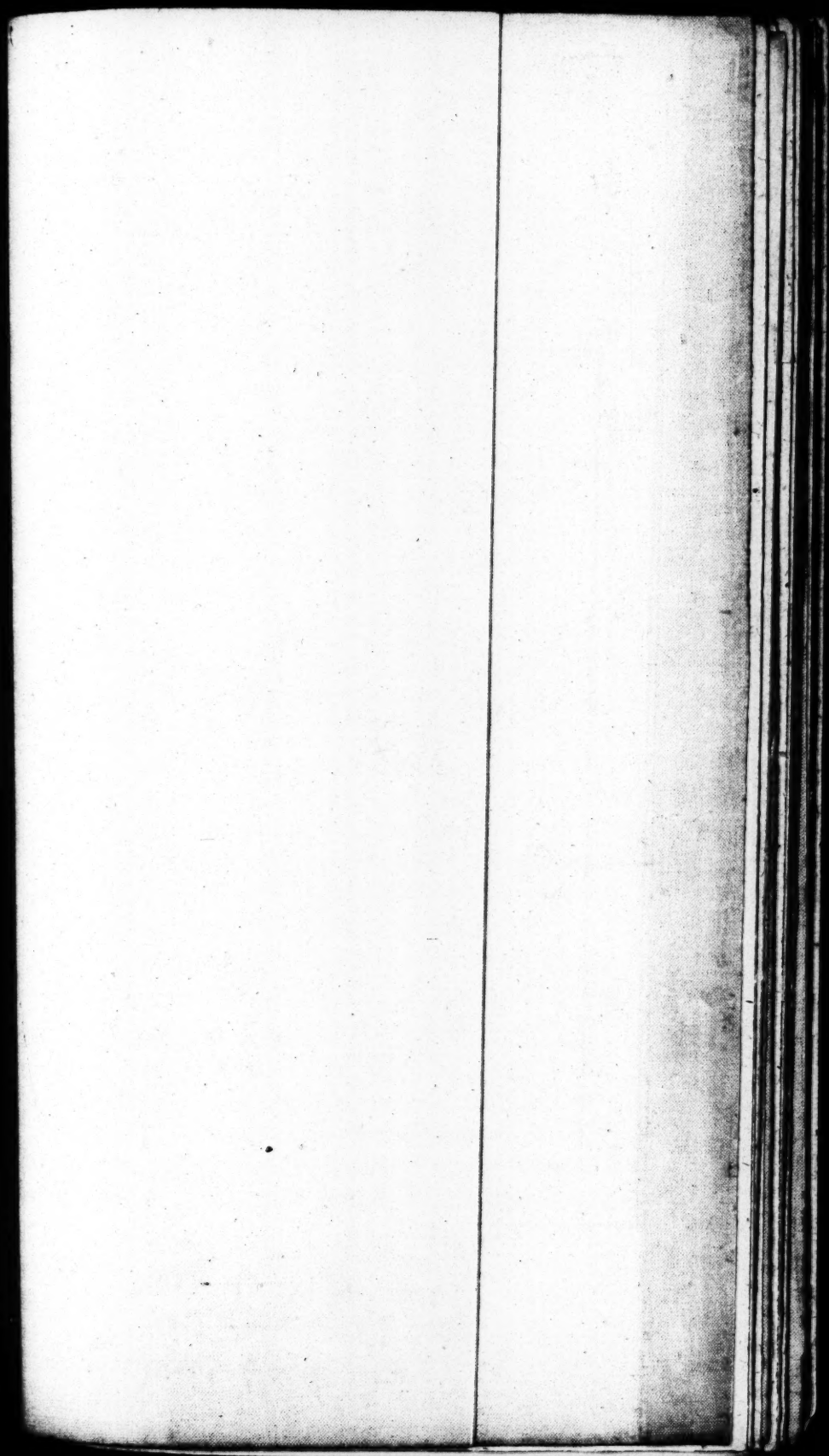
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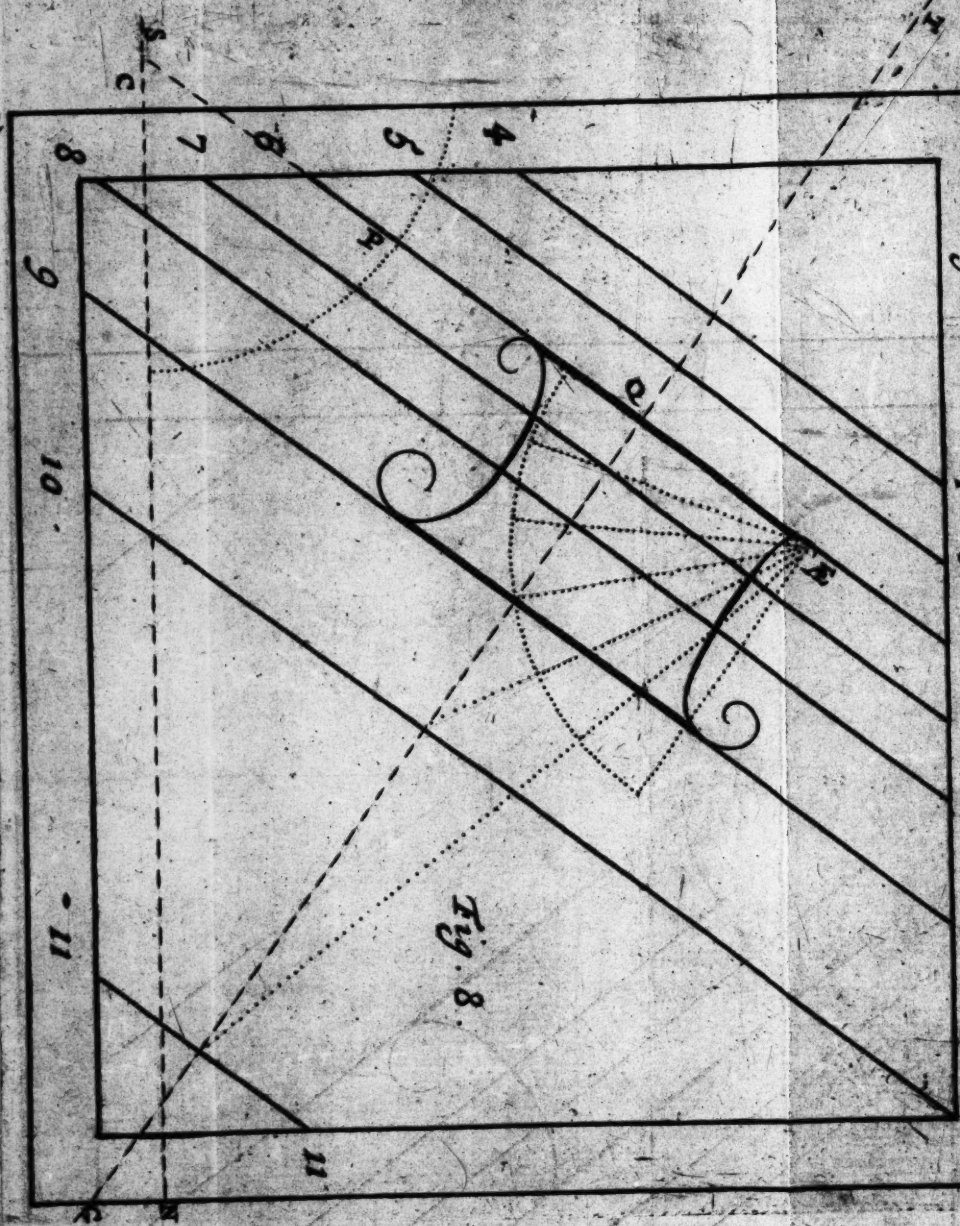
The Civil Solar Year too long by eleven Minutes; and of the Gregorian Reformation of the Calendar caused thereby.

intending to bring back the Equinox to the Time of the Year it fell upon at the *Nicene Council*, ordered *October 5th*. (in the Year 1582.) to be reckoned *October 15th*, thereby suppressing ten Days, and making the following *March 11th* to be reckoned *March 21st*; and so the Vernal Equinox which otherwise would have been reckoned to fall on *March 11th*, fall on *March 21st*, as at the Time of the *Nicene Council*. And that the Variation might not happen again, the said *Pope* ordered, that once in 123 Years a Day should be taken out of the Calendar; or (which comes to the same) that three Days should be taken out every four Hundred Years after this Method, viz. whereas, according to the Account afore (and still by us) used, every Hundredth Year from the Nativity of our Saviour is a *Leap-Year*; from thenceforth only every four Hundredth Year should be a *Leap-Year*; and the other Hundred Years should be common Years.

19.
Old-Style
and New-
Style,
what.

As the Account afore in use, thence called the *Old-Style*; as the *Julian Account* or *Julian Year* from *Julius Caesar*, by whose Auth





Place this facing pag. 26. Page 3

Dial plate f

A Direct & Dial

4 5 6 7 8 9

10



It was first introduced among the
Romans, forty-six Years before Christ:
 this Form of the Civil Solar Year
 introduced by the fore mentioned Pope
Gregory, is from him called the *Grego-*
rian Account; as also from its being
 comparatively with the former new-
 introduced, the *New-Style*. And
 is used in *Italy, France, Spain,*
 and where-ever the Pope's Authority is
 acknowledged; and as it had been
 received from the first by the *Popish*
Countries of Germany, so towards the
 end of the last Century it was received
 by many of the *Reformed People*
Germany, as to their Civil or Com-
 mon Account of Time. For as to
 their Ecclesiastical Account, or finding
 the *(Easter Moon, or) Time of Easter,*
 they follow the *Rudolphine Tables* of
1629. The *Old-Style* is still used by
 some of this Island, as also in *Ireland,*
 and by some others.

Although the Calends or First of
January is now-a-days, almost through-
 out all *Europe*, commonly looked on as
 the Beginning of the Year, whether
Roman or Gregorian; yet there are
 some who reckon the Beginning of
 the Year from some other Part of the Year.

Thus

20.
 Of the va-
 rious Be-
 ginnings
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 vil Solar
 Year in va-
 rious Coun-
 tries.

Thus the *Venetians, Florentines, and Pisans* in *Italy*, and the *Inhabitants of Triers or Treves* in *Germany*, reckon the Beginning of the Year from the Vernal Equinox. The Church of *England*, in Conformity to the Ancient Usage of the Christian Church, reckons her Ecclesiastical Year from the Feast of the Annunciation, commonly called by us *Lady-Day*. As our Civil Year, according to our Law, takes also its Beginning from the same Day; though the common People and others among us in Matters requiring the Nicety of a Legal Date, reckon the Beginning of a Year from the first of *January*.

21.
The Astronomical
Lunar
Year now
adapted to
Civil Use;
and first of
the Wandering
Lunar Year.

It has been afore observed, that the Lunar Year, strictly or according to Astronomical Exactness, consists of 354 Days, 8 Hours, and a little more than 48 Minutes. But to adapt it also to Civil Use, the Civil Lunar Year is esteemed to consist only of 354 whole Days. So that the Difference between the Civil Lunar Year of 354 Days, and the Civil Solar Year of 365 Days, is an eleven Days; the former being so much shorter than the latter. Hence it comes to pass, that

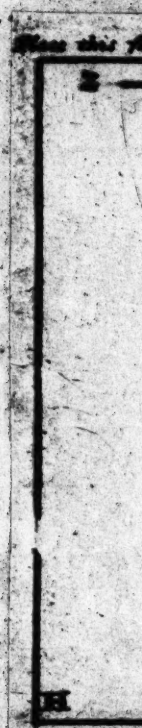
ch as use the Civil Lunar Year, without any Regard to the aforesaid Difference, their Year, supposing it to begin now in Spring, will after eight Years Time begin in Winter; and after eight Years more in Autumn, and so after that in Summer; and lastly, after about thirty-three Years in all, will begin in Spring again. Hence it is called *Annus Lunaris Vagus*, or the *Wandering Lunar Year*; because its Beginning thus wanders through the several Seasons, and that in the Memory of Man. And this is the Sort of Year used by the Turks.

Others, though they used or use the Civil Lunar Year, yet remedy the fore-mentioned Inconveniency of its thus changing the Time of its Beginning, by having Regard to the fore-mentioned Difference of eleven Days, between the Civil Solar and Lunar Year; namely, by intercalating so many Months, as the said Difference of eleven Days arise to in such a Number of Years. By which means the Lunar and Solar Year are kept so adjusted one to the other, as that the beginning of the Lunar Year will keep

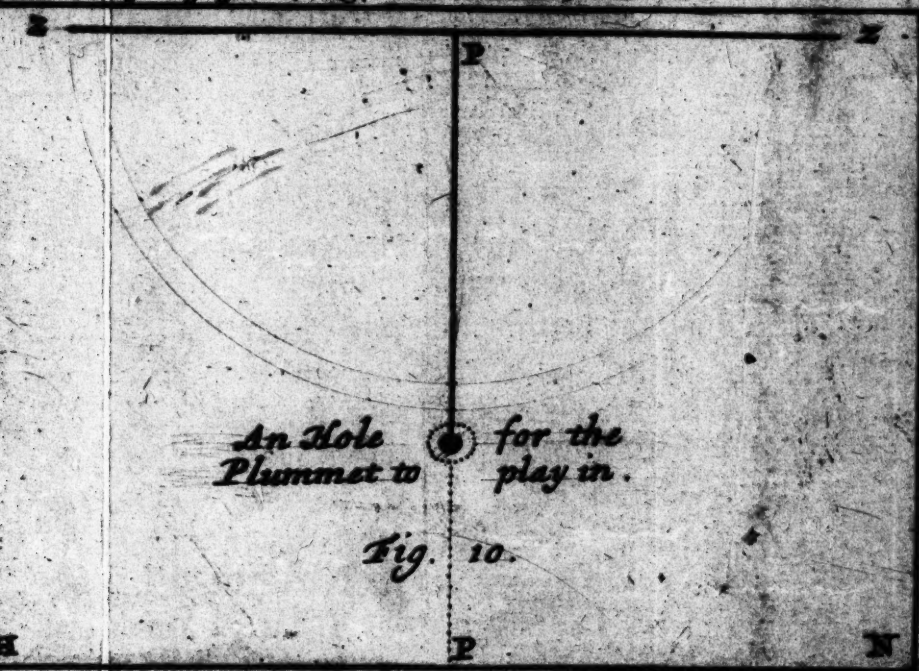
22.

Of the fixed Lunar, or Luni-Solar Year.

keep in a manner fixed to the Part of the Solar Year. Hence Sort of Year is called the *fixed* Year; as also the *Luni-Solar* Year and it is used by the *Jews*, and Church of *Rome* in her Ecclesiastical Account. And thus much for the several Parts, into which Time in general is distinguished.



as this being Fig. 30. A 3. Dial. Plate 5.



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Of the Characters of Time.

C H A R I I I

Of the several Characters of Time in general; and particularly of the Cycle of the Moon, and the Epacts.

Proceed we now to speak of the several Characters, whereby particular Times are distinguished one from the other. And these are either Natural or Instituted by Men.

The Natural Characters of Time are such as depend on Natural Causes, and are these; viz. New Moons, Full Moons, Eclipses, either of the Sun or Moon, the two Equinoxes, the two Solstices, the Cycle of the Moon, and the Epacts of the Moon. All which have been sufficiently spoken of in the foregoing Treatise of Astronomy, except the Cycle and Epacts of the Moon; which are therefore to be here explained.

14
The Characters of Time are of two kinds, Natural and Instituted.

2.
The Natural Characters of Time, what.

The

32

Of the Cycle of the Moon.

Of the Cycle of the Moon.

The Cycle of the Moon then is be esteemed a (+) Natural Character of Time, because it depends on Natural Cause, viz. the Motion the Moon: which is such, that, at nineteen Years very nearly, the New Moons and Full Moons are observed to fall on the same *Nachtbemerken* the Julian Year, as they did nineteen Years afore. Hence this Cycle is therwise termed the *Cycle of nineteen Years*.

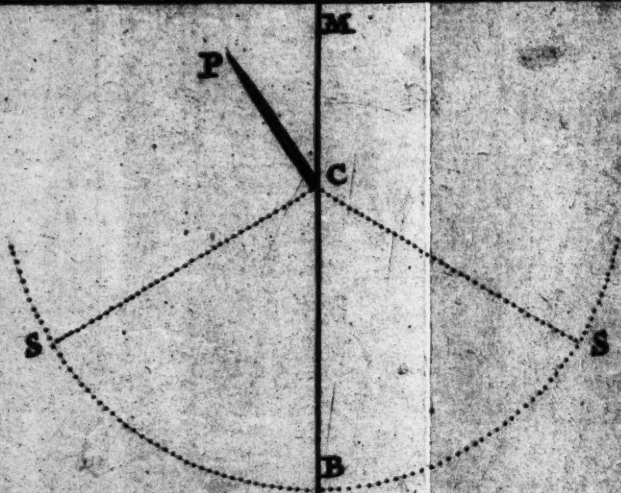
43
Of the Golden Number, or Prime.

The New Moons being observed fall out thus, they were wont formerly to calculate or find out the Time the New Moons (without the Help of Astronomical Tables) after this manner. They observed, on what Day of each Calendar Month the New Moons fell, in each Year of this Cycle, and to the said Days they set respectively the Number of the said Year. Thus observing, that the New Moon in the first Year of this Cycle, fell January 23d, February 21st, March 23d,

(+) Some esteem this, not a *Natural*, but an *Instituted*, Character of Time. But not so properly, since it depends on a *Natural Cause*.

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Fig. 11



A Plane, whose Meridian Line ML is to be found: C . denotes y^e Center or Place where y^e Pin CP is set up: CS & CB denote y^e two shades of y^e Pin: B . denotes y^e middle point of the Arch SB .

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etc. they set the Number 1 to the said Days. And in like manner, observing that, in the second Year of this Cycle, the New Moons fell on *January 12th, February 10th, March 12th*, etc. to the said Days they set the Number 2. And after this Method they went through all the nineteen Years of this Cycle; as may be seen (1) in the Calendar adjoyning to the End of this Chronological Treatise. The Numbers thus set to the Days, whereon the New Moons fell in each Year, are called the *Golden Numbers*, either because they were formerly wont to be writ in Gold, or else because of their Golden or Great Use. Any one of these Golden Numbers is otherwise called the (*) *Prime*, because the said Numbers were placed in the Prime or First Column of the Calendar, as they still are in our Church Calendar, and in the Calendar adjoyning to this Treatise. The

(1) As also in the Calendar of the Common-Prayer-Book.

(*) It is called by this Name in the Directions belonging to the Table for finding Easter for ever in the Common-Prayer Book.

Golden Numbers being thus placed it was easy to find, what Day of any Month in any Year given the New Moon would fall upon, it being known to what Year of the Moon's Cycle the Year given answered. Thus suppose, A. D. 354, to be the Year given, which answers to the 13th Year of the Moon's Cycle; and suppose it to be enquired, what Day of *March* the New Moon fell upon that Year: I look for the Number 13 in the Month of *March*, and find it to be the 11th Day; whereby is shewed that the New Moon fell that Year on that Day of *March*.

5.
How to
find the
New
Moons at
present by
the Golden
Number.

And by this Method the New Moons could be found with Accuracy enough at the Time of the *Nice Council*; forasmuch as the Golden Number did then shew the Day (i. e. the *Nuchthemeron*) within which the New Moon fell out. And hereupon is founded the *Rule* of the *Nice Council* for finding *Easter*, of which more in Chapter 7th. It is here to be observed, that the Golden Numbers do not now shew the Day whereon the New Moons fall. For the Cycle of the Moon is less than

nineteen

nineteen *Julian* Years, by 1 Hour, 27 Minutes, and almost 32 Seconds. Whence it comes to pass, that, although the New Moons fall again upon the same *Days*, as they did nineteen Years afore, yet they fall not on the same *Hour* of the Day or *Nuchthemeron*; but 1 Hour 27 Minutes, and almost 32" Sooner. And this Difference arising in about 312 Years to a whole Day, hence the New Moons after every 312 Years fall a whole Day (*i. e.* *Nuchthemeron*) sooner. Upon this Score the New Moons fall now four Days sooner, than they did at the Time of the *Nicene Council*. Which being observed, the Day (*i. e.* the *Nuchthemeron*, though not the Hour of it) on which the New Moons fall, may be now found by the Golden Number. For instance, I would know on what Day of *January* the New Moon will fall next Year, *viz.* 1712. This, by the Rule delivered in the following Paragraph, will be found to be the third Year of the Moon's Cycle. I look therefore for the Golden Number 3, and find it in the Calendar) placed to *January* the 1st, and again to *January* the 31st.

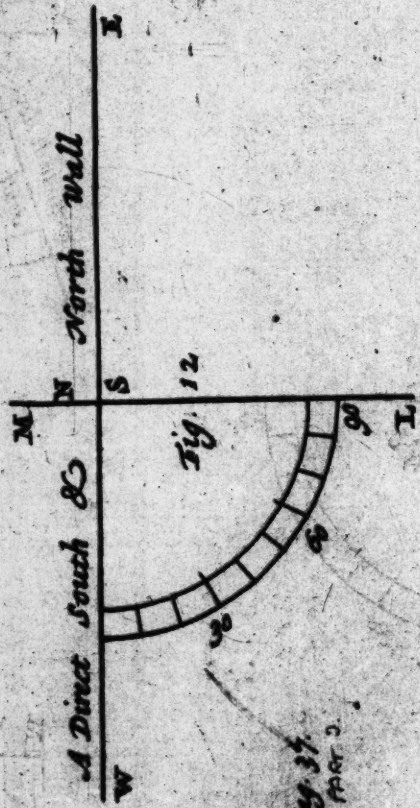
so that about the Time of the *Nicen Council*, there were two New Moons in the Month of *January*, every third Year of the Moon's Cycle. Whereas according to the fore-mentioned Observation, each of the said two New Moons falling now four Days sooner the first of them falls upon *December 28th* of this present Year, 1711 and only the other falls in the *January* following, viz. on *January 27th* 1712.

6. It remains now to shew, how it is to be found, what Year of the Moon's Cycle any given Year of Christ answers to. And this is done by (†) adding 1 to the given Year of Christ and then dividing the Sum by 19. 19 just divides the Number of the Year given, then it is the 19th or last Year of the Moon's Cycle; if it does not just divide the said Number but somewhat of the said Number remains over, then the said Remainder shews the Year of the Moon's Cycle. For instance, I would know to what Year of the Moon's Cycle A. D. 1711

To find,
what Year
of the
Moon's
Cycle any
given Year
of Christ
answers to.

(†) The Reason of adding 1 is, because the Year of Christ began in the second Year of this Cycle.

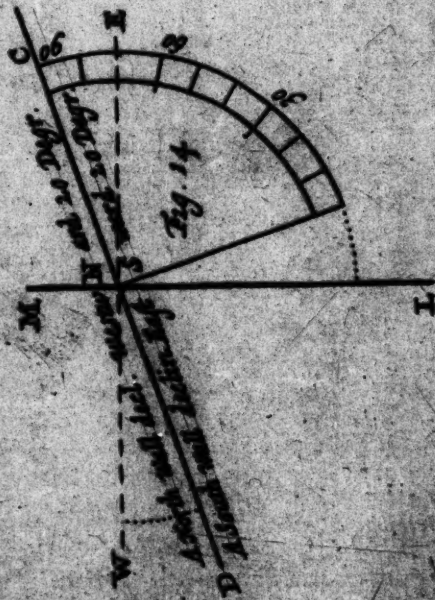
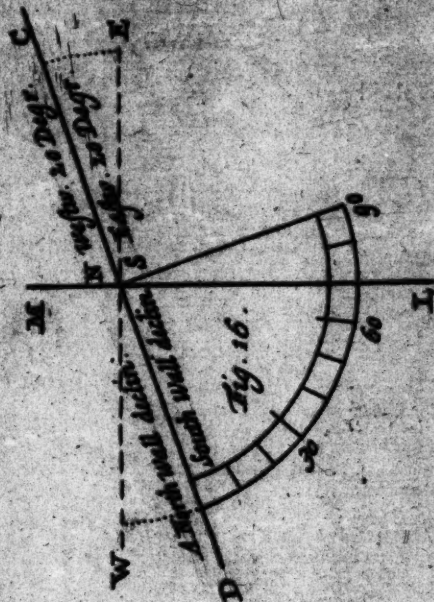
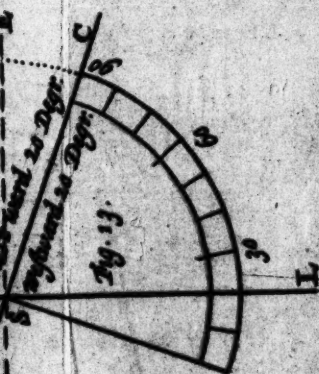
(2)



Dial. Plate 7.

Place this facing Fig. 37.
PART 2.





answers. And by this Rule I find it to answer to the third Year of the Cycle ; for $1712 + 1$ being divided by 19, there will remain 3. And thus much for the Cycle of the Moon.

Come we next to the Epacts of the Moon; It has been afore observed, that the Civil Lunar Year is eleven Days shorter than the Civil Solar Year. Consequently, two such Lunar Years will be twenty-two Days shorter than two such Solar Years ; and three Lunar Years will be shorter than three Solar Years by thirty-three Days. Now such as use the fixed Lunar (otherwise called the Luni-Solar) Year, in order to adjust the said Lunar Year to the Solar, as often as the Lunar Year does thus come to be thirty-three Days shorter than the Solar, do intercalate a Month of thirty Days into the Lunar Year ; except only every 9th Year (*viz.* the last Year of the Moon's Cycle) when the intercalated Month consists but of twenty-five Days.

7.
Of the Epacts of the Moon.

By this means the Civil Lunar and Solar Years are kept so adjusted together, as that the first Year of the Moon's Cycle comes not shorter of the Solar Year than eleven Days; the second Year of the said Cycle not shorter than twenty-two Days; the third Year shorter only by three Days, &c. as may be seen

Golden Number.	Epaets.
1 . . .	. XL
2 . . .	. . XXII.
3 . . .	. . . III.
4 . . .	. . . XIV.
5	. . . XXV.
6	. . . VI.
7	. . . XVII.
8	. . . XXVIII.
9 . . .	. . . IX.
10 . . .	. . . XX.
11 . . .	. . . I.
12 . . .	. . . XII.
13 . . .	. . . XXIII.
14 . . .	. . . IV.
15 . . .	. . . XV.
16 . . .	. . . XXVI.
17 . . .	. . . VII.
18 . . .	. . . XVIII.
19 . . .	. . . XXIX.

in the adjoining Table. Namely, the New Moons are the same (*i. e.* fall on the same Day) every nineteen Years, so the Difference between Lunar and Solar Year is the same every nineteen Years. And because the said Difference is always to be added to the Lunar Year, in order to adjust or make it equal to the Solar Year, hence the said Difference respectively belonging to each Year of the Moon's Cycle, is called the *Epaet* of the Year, *i. e.* the Number to be added to the said Year to make it equal to the Solar Year.

Of the Epact of the Moon.

39

8.

How to
find the
Epacts of
the Moon
according to
the Julian
Account.

Upon this mutual Respect between the Cycle of the Moon, and the Cycle of the Epacts, there is founded this Rule for (||) finding the Epact belonging to any Year of the Moon's Cycle. Multiply the Year given of the Moon's Cycle into 11; if the Product be less than 30, it is the Epact sought; if the Product be greater than 30, divide it by 30; and the Remainder of the Dividend is the Epact. *Ex. gr.* I would know the Epact for A. D. 1712, which has been already found to be the third Year of the Moon's Cycle. Wherefore three is the Epact for A. D. 1712: for $11 \times 3 = 33$, and 33 being divided by 30, there is left three of the Dividend for the Epact.

(1) Namely in respect of the *Julian Account*. For respect of the *Gregorian Account* there is a different Method, the Epact being different. However, the *Julian Epact* being known, it is easy thence to know the *Gregorian Epact*. Namely, if the *Julian Epact* be greater than 11, Subtract 11 from it: if less, add 30 to it, and out of the Sum Subtract 11, and the Residue will be the *Gregorian Epact*. For instance; it has been found, that Three is the *Julian Epact* for A. D. 1712. Wherefore $3 + 30 = 33$, and $33 - 11 = 22$, which last Number (*viz.* 22) is the *Gregorian Epact* for the said Year, 1712.

D 4

By

9.

To find by
the Epacts,
what Day
of any
Month in
any Year
the New
Moon falls
on.

By the Help of the Epact may be found, what Day of any Month in any Year the New Moon falls on thus: To the Number of the Month from *March* inclusively, add the Epact of the Year given; if the Sum be less than 30, Subtract it out of 30; if greater, Subtract it out of 60; and the Remainder will be the Day, whereon the New Moon will fall. Now if the New Moon be sought for the Month of *January* or *March*, then nothing is to be added to the Epact; if for *February* or *April*, then only 10 is to be added. *Ex. gr.* I would know what Day of *December* the New Moon will fall on this A. D. 1711, the Epact whereof is 22. By the aforesaid Rule, I find it will be *December* 28 for $22 + 10 = 32$, and $60 - 32 = 28$.

10.

To find the
Age of the
Moon.

The Day, whereon the New Moon falls, being thus found, it is easy to find from thence to infer, what the Age of the Moon is on any Day given. However, there is a peculiar Rule commonly made use of to this purpose which is this: Add the Epact of the Year, the Number of the Month from *March* inclusively, and the given Day of the Month all into one Sum, which

which, if it be less than 30, shews the Age of the Moon; if it be greater than 30, divide it by 30, and the Remainder of the Dividend shews the Age of the Moon, or how many Days it is from the last New Moon. And this Method will never err a whole Day. For instance, I would know, what will be the Age of the Moon on December 31st of this Year 1711. By this Rule I find, that the Moon will then be three Days Old, *i. e.* that it will then be three Days from the last New Moon. For $22 + 10 + 31 = 63$, and 63 being divided by 30, there will remain of the Dividend 3. And this exactly agrees to the other foregoing Rule, whereby it was found, that the New Moon will fall on December 28th of this Year 1711.

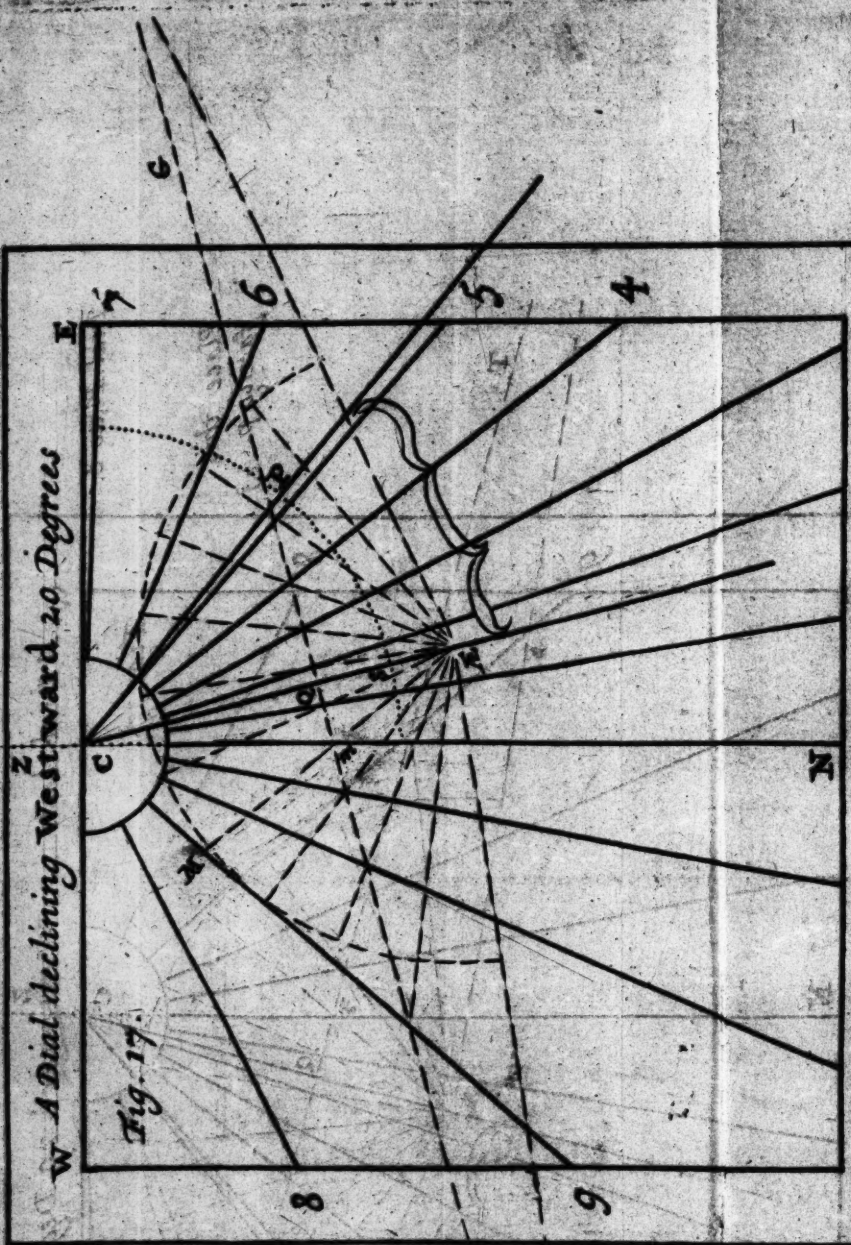
It remains only to observe, that the Epacts of the Moon are justly to be esteemed as (*) Natural Characters of Time; forasmuch as they depend on a Natural Cause, *viz.* the Motion of the Moon. For the Reason, why

II.
*The Epacts
of the Moon
are to be
esteemed
Natural
Characters.*

(*) This is insisted upon, because the Epacts are by some esteemed, not *Natural*, but *instituted* Characters.

the Civil Lunar Year is less than the Civil Solar (*i. e. Julian*) Year by eleven Days, is, because as the Moon goes round her *Orbit*, there are twelve Conjunctions of her and the Sun, (or twelve Synodical Months, which make up a Lunar Year) in less Time by eleven Days very nearly, than the Sun seems to go once round the Earth. And in like manner, the Reason why the Cycle of the Epacts, as well as that of the Moon, consists of nineteen Years, is, because in that Interval of Time, the Moon's Motion has (much) the same Respect to the Sun as it had nineteen Years afore. And thus much for the *Natural* Character of Time.

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W A Dial declining Westward 20 Degrees

Fig. 17.

Dial Plate B.

Place this
facing p. 43.

Fig. 2



C H A P. IV.

Of the Cycle of the Sunday-Letter,
commonly called the Cycle of
the Sun.

THE Cycle of the Sun is very properly so called, forasmuch as it relates not to the Course of the Sun, but to the Course of the Dominical or Sunday-Letter; whence it ought to be called the Cycle of the Sunday-Letter. It consists of twenty-eight Years, forasmuch as after every twenty-eight Years, the Course or Order of the Sunday-Letter is the same, as it was before.

I.

The Cycle of the Sun improperly so call'd.

The Use of this Cycle arises from the Custom of Assigning in the Calendar to each Day of the Week, one of the first seven Letters of the Alphabet; A being always affixed to

2.

Of the Use of this Cycle.

(*) This Custom being Arbitrary, hence this Cycle is not a Natural Character, but of Humane Institution.

January

January 1st, whatever Day of the Week it be; *B* to *January 2^d*, *C* to *January 3^d*; and so in order *G* to *January 7th*. After which the same Letters are repeated again, *A* being affixed to *January 8th*, &c. According to this Method, there being 52 Weeks in a Year, the said seven Letters are repeated 52 Times in the Calendar. And were there but just 52 Weeks, the Letter *G* would belong to the last Day of the Year, as the Letter *A* does to the first; and consequently, the Letter, which was at first constituted the *Sunday-Letter*, (and the same to be understood of the other Days of the Week) would always have been so; and there would have been no Change of the *Sunday-Letter*. But our Year consisting of 52 Weeks, and an odd Day over, hence it comes to pass, that the Letter *A* belongs to the last, as well as to the first Day of every Year. For, although every Leap Year consists of 366 Days, and so of two Days over 52 Weeks, yet it is not usual to add a Letter more, or *B*, to the End of the Year; but instead thereof to repeat the Letter

wh

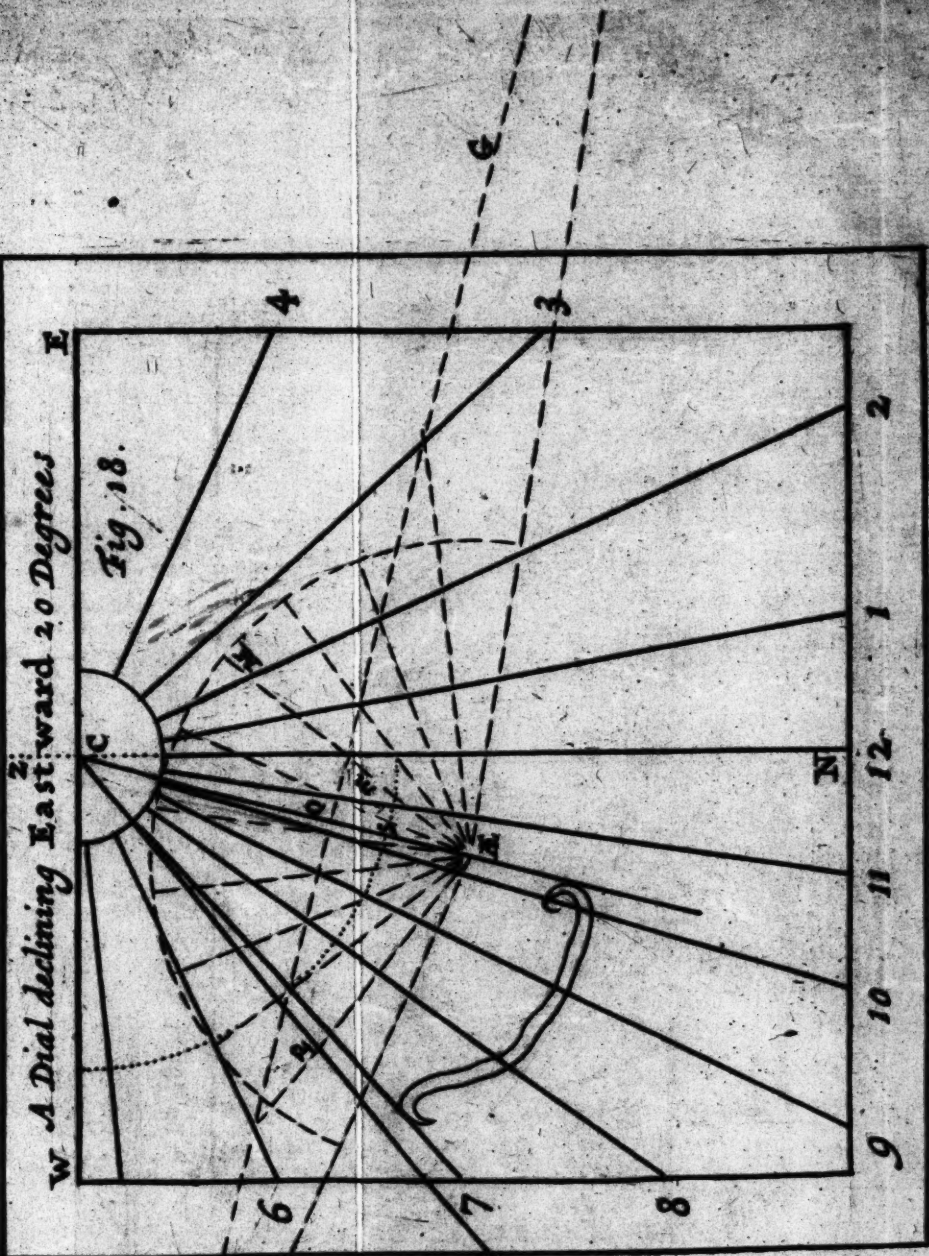
W. A Dial declining Eastward 20 Degrees E

Fig. 44.

PART 2.

W A Dial declining Eastward 20 Degrees E

Fig. 18.



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which (†) answers to the 24th of February, and to affix it again to the intercalated Day (as has been afore observed) which we call *February 25th*. By which means the said seven Letters of the Alphabet remain affixed to the same Days of a Leap-Year, as of a Common Year, through all the Rest of the Calendar, both before and after. The Letter *A* then thus always belonging to the first and last Day of the same Year, and consequently to the last Day of the Old Year, and first Day of the New; it thence comes to pass, that there is a Change made as to the *Sunday-Letter* in a backward Order, that is, supposing *G* to be the *Sunday-Letter* one Year, *F* will be the next, and so on: which is illustrated by the following Table; where it must be observed, that the great Letter is the *Sunday-Letter* for each Year.

(†) As may be seen in the Calendar adjoined to the End of this Treatise.

December

December 1711.

a . . . 24 Monday
 b . . . 25 Tuesday
 c . . . 26 Wednesday
 d . . . 27 Thursday
 e . . . 28 Friday
 f . . . 29 Saturday
 G . . . 30 Sunday
 a . . . 31 Monday

January 1712.

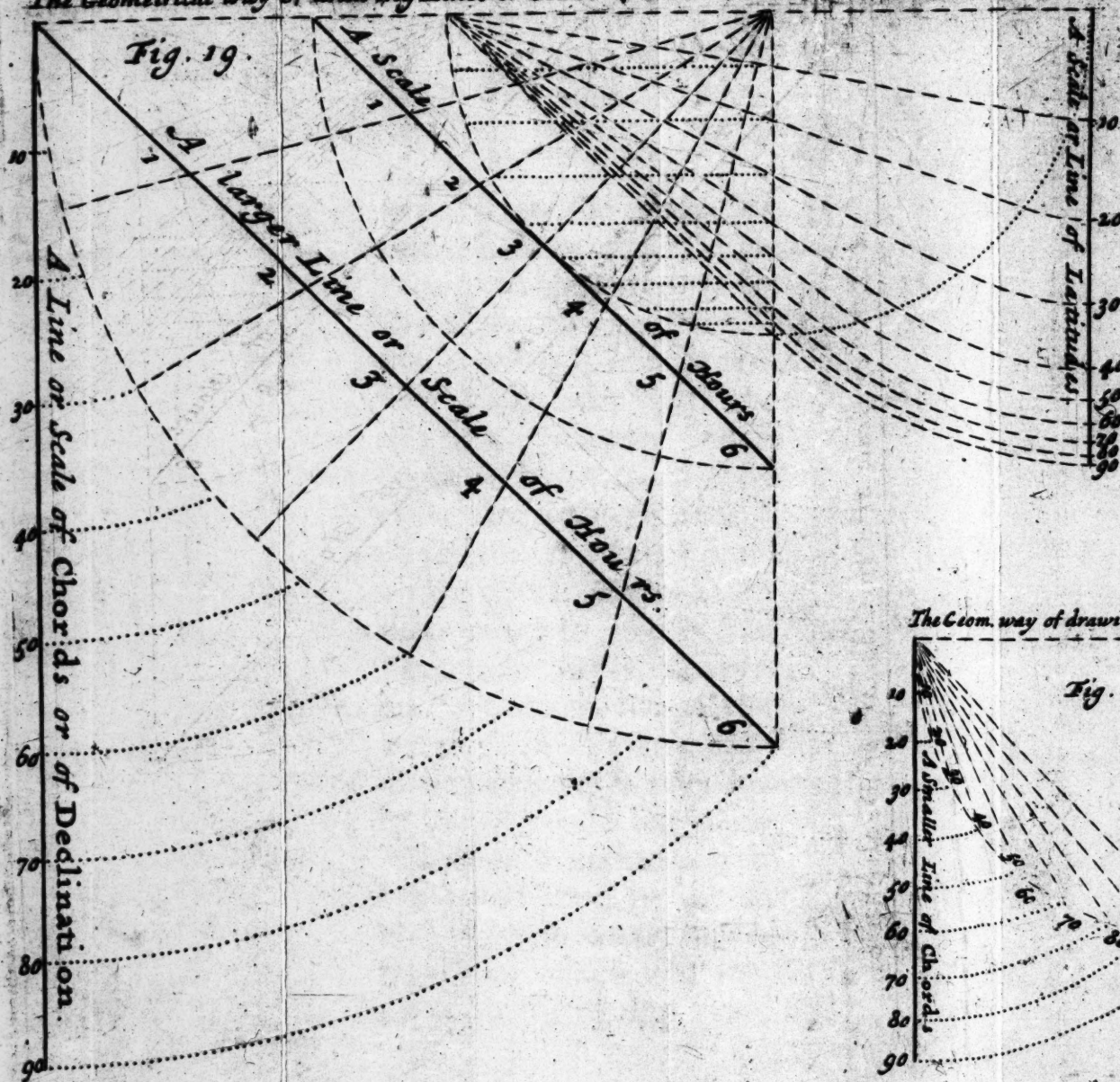
a . . . 1 Tuesday
 b . . . 2 Wednesday
 c . . . 3 Thursday
 d . . . 4 Friday
 e . . . 5 Saturday
 f . . . 6 Sunday
 G . . . 7 Monday
 a . . . 8 Tuesday

3.
 The odd
 Day in
 every Com-
 mon Year,
 makes a
 single
 Change in
 the Sun-
 day-Let-
 ter.

As from the foregoing Table it is evident, how the odd Day above 52 Weeks in a Year does make the Sunday-Letter change from one Letter to the next to it in a backward Order so it is obvious, that were there but this single Change, Sunday would be denoted by each of the seven Letters every seven Years, and so the Cycle of the Sunday-Letter would consist of no more than seven Years. But now there being in every fourth or Leap Year two Days above 52 Weeks hence it comes to pass, that there is every such Year a double Change made as to the Sunday-Letter. Namely, as the odd single Day above 52 Weeks in a common Year, makes (as has been shewn by the foregoing Table) the first Sunday in January to shift from that which was the Sunday-Letter of the foregoing Year, to the next Letter.

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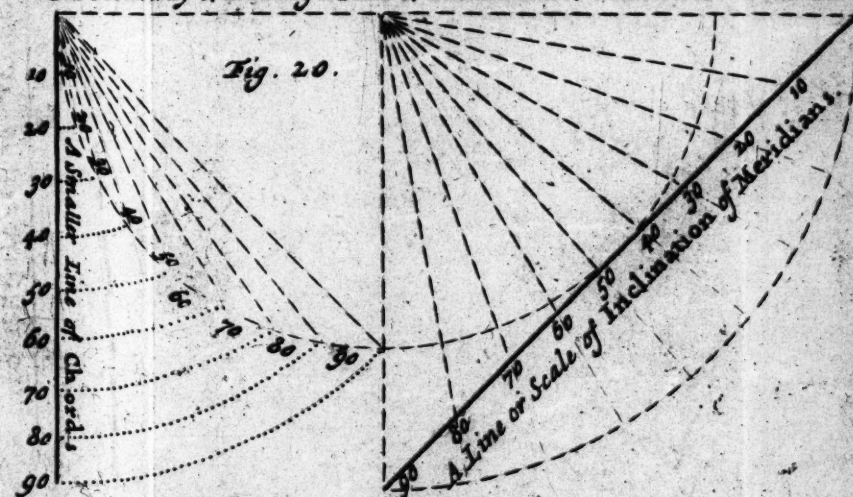
The Geometrical way of drawing Lines or Scales of Hours, Latitudes, Declination or Chords.



Dial. Plate 9.

Place this facing pag. 47.
Part 3.

The Geom. way of drawing a Scale of Inclination of Meridians & Chords.



Letter to it in a backward Order ; so the other Day, intercalated every Leap-Year after the 23d of *February*, (though it makes no Change as to the Days of the *Month*, to which the Alphabetical Letters respectively belong ; which is brought about by the Artifice of repeating the Letter *F* twice, as was afore observed : yet it does make a Change as to the Days of the *Week*, to which each Alphabetical Letter is to belong for the remaining Part of the Year ; as is evident by the following Table, containing the latter Part of *February* 1712, being Leap-Year, and the former Part of *March*.

February:

23	c	Saturday
24	F	Sunday
25	f	Monday
26	g	Tuesday
27	a	Wednesday
28	b	Thursday
29	c	Friday

March:

1	d	Saturday
2	E	Sunday
3	f	Monday
4	g	Tuesday
5	a	Wednesday
6	b	Thursday
7	c	Friday

As the former Table shewed, how 4. comes to pass, that G is the *Sunday*-The intercalated Day makes a double Change in the Sun-shews, after for 1711, and F for 1712, at the Beginning of the said Year, even *February* 23d ; so this latter Table

day-Letter
every
Leap-Year.

shews, how it comes to pass, that after *February 23d*, not *F* as afore, but *E* is the *Sunday-Letter* for the Rest of the Year. And consequently as the former Table will serve to shew, how by the odd Day in a common Year there is made every common Year single Change as to the *Sunday-Letter* so the latter Table, compared with the former, will shew how by the intercalated Day of a Leap-Year there is made after *February 23d*, in every Leap-Year another Change of the *Sunday-Letter*, besides the former made at the Beginning of the said Leap-Year; and consequently how there comes a double Change of the *Sunday-Letter* every Leap-Year.

5.
This Cycle
why con-
sists of
twenty-
eight
Years.

Now as the Cycle of the *Sunday-Letter* would have consisted but of seven Years, had there been only a single Change of the said Letter; by Reason of there being a double Change of the said Letter every Leap or fourth Year, it comes to pass, that the said Cycle consists of four Times seven Years, *i. e.* the *Sunday-Letter* does not proceed in the same Course as it did afore, under twenty-eight Years; and after that Number

Of the Cycle of the Sun.

49

ears its Course or Order is the same
it was afore. Which is illustrated
the following Table; where it is
be observed, that the first Year,
and every fourth Year after, of the
ycle is a Leap-Year, and therefore
two *Sunday-Letters* appertaining
it.

TABLE of the Cycle of the Sun.

5 BA	9 DC	13 FE	17 AG	21 CB	25 ED
6 G	10 B	14 D	18 F	22 A	26 C
7 F	11 A	15 C	19 E	23 G	27 B
8 E	12 G	16 B	20 D	24 F	28 A

To find what Year of this Cycle any
ven Year of our Lord answers to,
and consequently, what is the *Sunday-*
letter for the Year given, work thus:
to the Year of our Lord given (||)
9, and divide the Sum by 28. If

7.

To find the
Cycle of
the Sun for
any given
Year of
Christ.

(||) The Reason of adding 9, is, because the *Æra*
Christ began in the Tenth Year of this Cycle.

E

any

any of the Dividend remains, the Remainder shews the Year of the Cycle sought; if nothing remains of Dividend, then it is the last or 28th Year of the Cycle. For instance, to know, what Year of the Cycle of the Sun, A. D. 1712 answers By the foregoing Rule I find it to answer to the 13th Year of the said Cycle; (for $1712 \div 9 = 1721$, and 1721 being divided by 28, there will be left 13;) and by the Table of Cycle I find the *Sunday-Letters* of the said Year, being a Leap-Year, to be *FE*, viz. *F* from the Beginning of *January* to *February 23d*, and *E* for the Rest of the Year, according to the (*) *Julian Account*.

8. It may not be altogether unnecessary to observe further, that each of the first seven Alphabetical Letters always (as is afore noted) belonging to the same Day of each Month in the Year, hence the two following *English* Ver-

To find,
what Day
of the
Week the
first Day of
any Month
falls upon.

(*) Having found the *Sunday-Letter* according to the *Julian Account*, the *Gregorian Sunday Letter* will be the third in a backward Order from the *Julian*. Thus *FE* being the *Julian Sunday-Letters* for a Leap-Year, *CB* will be the *Gregorian Sunday-Letters* for the same.

Of the Cycle of the Sun.

51

new by the first Letter of each Word,
that Letter belongs to the *first* Day
of each Month; the Order of the
Words answering to the Order of the
Months thus:

Jan. Feb. March, April, May, June,
at Dover Dwells George Brown Esquire,
July, Aug. Sept. Oct. Nov. Dec.
and Christian Faith, And Doctor Fryar.

Wherefore the *Sunday-Letter* being
known, it is easy by the Help of the
 foregoing Verses to tell, what Day of
 the Week the first Day of any Month
 falls upon; namely, by considering
 the Order or *Distance* of the Letter
 belonging to the first Day of the given
 Month from the given *Sunday-Letter*.

Ex. gr. I would know, what Day of
 the Week the first of *February* 1712
 will be, when the *Sunday-Letter* will
 (at that Part of the said Year) *F*.
 By the foregoing Verses I know *D* is
 the Letter belonging to *February 1st*,
 and therefore *F* being the *Sunday-Let-*
 ter, *D* (as being two in the Alphabe-
 tical Order before *F*) must denote
 Friday, which is agreeably two Days
 before *Sunday*.

In like manner, if it be enquired what Day of the Week *March 1* will fall upon in 1712, when the *day-Letter* will be changed from *F* to *E*. It being known by the foregoing Verses, that *D* is the Letter that belongs also to the first of *March*, it follows that, as *D* is the Letter next before *E*, so *March 1st* must fall (that Day of the Week which is next before *Sunday*, viz.) *Saturday*.

9.
To find,
what Day
of the
Week any
other Day
of the
Month (be-
sides the
first) falls
upon.

It being thus to be known, what Day of the Week the *first* Day of any Month falls upon; thereby may easily known also, what Day of the Week any other Day of the same Month falls upon; namely, by considering, that the 1st, 8th, 15th, 22nd and 29th Day of any Month always fall upon the same Day of the Week, and then reckoning, how far distant the Day proposed is from any of the aforesaid Days. For instance, I would know, what Day of the Week *March 18th* falls upon next Year, viz. 1712. It being afore known, that the Day of *March* will then fall on *Saturday*, it follows, that *March 15th* will be likewise on *Saturday*; and therefore *March 18th* (as being three Days

After *March 15th*) will fall on *Tuesday*,
being three Days after *Saturday*.
And therefore, by the *Sunday-Letter*
and the foregoing Verses, may be
found, what Day of the *Week* any
Day of the *Year* in general will fall
upon. And thus we have largely
shown the Use of the Cycle of the
Sun, or of the *Sunday-Letter*.

E 3

CHAP,

C H A P. V.

Of the Indiction, and Julian Period.

I.
of the
Indiction.

THE Indiction is a Cycle of fifteen Years, which has no Relation to any Celestial Motion, but was instituted wholly on a Political or Civil Account, viz. in respect to certain Taxes (as is the most received Opinion) which were to be paid every fifteen Years. When this Cycle was first instituted, is not left upon Record; but it is evident from History that it has been in Use ever since the Time of *Constantine the Great*, from A. D. 312. It was used both by the *Greeks* and *Romans*, but at a manner somewhat different. The *Roman* Indiction is still used by the *Pope* in his Bulls, &c. And the Year of the *Roman* Indiction answers

(†) The *Greek* Indiction begins from the first of September, the *Roman* Indiction from the first of January. And the former is used in the *Acts of Councils* and the *Novels* of the Emperors.

ing to any given Year of Christ is found, by (H) adding 3 to the given Year of Christ, and dividing the Sum by 15. The Remainder of the Division, if any there be, shews the Indiction; if nothing remains, then it is the 15th or last Year of the Indiction. The principal Reason of taking Notice of this Cycle in this Treatise, is because it conduces to the Understanding of the *Julian Period*, of which we shall speak next.

The *Julian Period* is no other than the greater Cycle, made up of the three pre-mentioned Cycles of the Moon, Sun, and Indiction, multiplied one to the other, and so consisting of 7980 Years. For the Cycles of the Moon and Sun, viz. 19 and 28, being multiplied together make (*) 532; which being multiplied again by 15, the Cycle of the Indiction, makes 7980,

2.
Of the Julian Period.

(H) The Reason of adding 3, is, because A. D. 1. began in the fourth Year of the said Roman Indiction.

(*) This Number of Years, arising from the Cycles of the Moon and Sun being multiplied together, is familiarly stiled the *Dionysian Period*, and also the *Julian Period*, from Persons of the like Names who introduced the Use thereof.

the Space of the *Julian Period*. It is called the *Julian Period*, because was adapted by the Author or Inventor of it *Joseph Scaliger*, to the *Julian Year*, and its fore-mentioned Cycle. It is of excellent Use in Chronology or Distinguishing of Times; because the same Years of the Cycles of the Moon, Sun, and Indiction, which belong to any one Year of this *Julian Period*, will never fall together again till after 7980 Years, and consequently not as long as the World stands according to the Opinion probably received concerning (†) the Duration of the World. And as this Period will probably not expire before the End of the World, and thereby consequently may be distinguished the Times of all *Future Events*; so it tends backwards (||) before the Beginning

(†) Namely, That it shall endure but 6000 Years. Of which about 4000 Years being expired before our Saviour's Nativity, and somewhat above 1700 Years being expired since, there remains but about 300 Years more for the World to last, according to the said Opinion.

(||) Namely, *Julian Period* 4714, answering to A. D. 1. and our Saviour being Born but about 4000th Year of the World, it thence follows, that the *Julian Period* must be conceived to commence begin about 700 Years before the Creation.

ning of the World, and thereby consequently may be distinguished the Times of all *Past* Events from the very Creation. Hence Chronologers do endeavour to adjust all other Accounts of Time, and consequently all Transactions and Events recorded in History, to the *Julian Period*.

To find, what Year of the *Julian Period* any given Year of Christ answers to, work thus. To the given Year of Christ add 4713, (because so many Years of the *Julian Period* were expired before A. D. 1.) and the Sum gives the Year of the *Julian Period* sought. For instance, I would know, what Year of the *Julian Period* A. D. 1712 answers to. Now $1712 + 4713 = 6425$, the Year sought of the *Julian Period*.

3.
To find,
what Year
of the Ju-
lian Pe-
riod an-
swers to
any given
Year of
Christ.

On the contrary, having the Year of the *Julian Period* given to find what A. D. answers thereto, work thus. From the Year of the *Julian Period* given, subtract 4713, (for the Reason above-mentioned,) and the Residue will be the A. D. sought. For instance, I would know, what A. D. answers to the *Julian Period* 6425.

4.
To find,
what Year
of Christ
answers to
any given
Year of the
Julian Pe-
riod.

Wherefore

Wherefore $6425 - 4713 = 1712$, the A. D. sought.

5.
To find,
what Year
before
Christ an-
swers to
any given
Year of the
Julian Pe-
riod, less
than 4714.

If the Year of the *Julian Period* given be 4713, or less than it, then Substra& the same from 4714. (which is the Year of the *Julian Period*, that answers to A. D. 1.) and the Residue will shew, how long afore (the Beginning of the common Computation from the Nativity of) Christ the given Year of the *Julian Period* was. For instance, the City of *Rome* is said to have been built, J. P. 3960. I would know therefore, how long it was built before Christ. Now $4714 - 3960 = 754$. Wherefore *Rome* was built 754 Years before (the Beginning of the common *Æra* of) Christ.

6.
To find the
Cycle of
the Sun,
Moon, or
Indiction,
answering
to any Year
of the Ju-
lian Pe-
riod.

To know, what Year of the Cycle of the Sun, Moon, or Indiction, answers to any Year given of the *Julian Period*; divide the given Year respectively by 28, or 19, or 15. The Remainder of the first Division will shew the Year of the Sun's Cycle; the Remainder of the second Division will shew the Year of the Moon's Cycle; and of the third Division, the Year of the Indiction. If nothing remains in each Division, then it is the last

last Year of each Cycle respectively.

On the contrary to know, what Year of the *Julian Period* answers to any given Year of the Cycle of the Sun, or Moon, or Indiction; multiply the Cycle of the Sun into 4845, the Cycle of the Moon into 4200, the Cycle of the Indiction into 6916. The Sum of the Products being divided by 7980, the Remainder will shew the Year of the *Julian Period* sought.

7.
And the
contrary.

And thus we have gone through the several Characters of Time, whose Computation after a certain Number of Years begins anew; whence each of them is stiled, either a *Cycle*, as the Cycle of the Sun, Moon, and Indiction; or a *Period*, as the *Julian Period*.

8.
Cycles and
Periods,
why so cal-
led.

C H A P.

C H A P. VI.

Of Epoch's or Æra's; and especially of the Æra or Year of Christ, the Æra of the Olympiads, and the Æra of the Building of Rome.

I.
Of Epoch's
or Æra's.

WE are now to speak of those Characters of Time, whose Computation does not begin anew after a certain Number of Years, but is still continued on further and further from their respective Heads or single Beginnings. And these are distinguished from the circular Characters of Time already described, by the Name of (*) Epoch's or Æra's.

2.
Of the
Æra of
Christ,
used by Us
and other
Christians.

There are several Epoch's or Æra's made use of, both formerly and at

(*) These Words are frequently used promiscuously. Some take an Æra to denote properly any continued Computation, and an Epoch to signify properly the Beginning of the said Computation; the Greek Word *ἐποχή* denoting (as it were) a Pause or Stop in Time, from whence Time is computed. As to the Etymology of Æra, there is no good Account of it.

present.

Of the Year of Christ.

61

present, in the several Parts of the World. That of principal Concern to us Christians is the *Æra* of *Christ*, or the common Way of computing Time from the Nativity of *Christ*; according to which this present Year is reckoned the 1711th from the *Nativity* of *Christ*, or rather from the *first of January* next following the *Nativity* of *Christ* according to the common Computation. The *Æra* or Way of Reckoning from *Christ*, was first introduced by one *Dionysius*, surnamed (†) *Exiguus*, somewhat more than 500 Years after *Christ*: Since which Time Christians have reckoned their Years, either from the Birth or Incarnation of our Blessed Saviour; whereas before they were wont to reckon some other Ways. According to *Dionysius*, the Author of the *Æra* computed from *Christ*, our Lord was conceived on the 8th of the Calends of *April* (now called *Lady-Day*) in the first Year of this *Æra*; and was Born about the Winter-Solstice next following, at the End of the 46th Year of

(†) He was so surnamed from his little Stature.

the

the *Julian Epoch*, or of the Reformation of the Year by *Julius Caesar*. And this Account was at first universally received among Christians; but is now a-days used only in *England* and *Ireland*, where not only the Ecclesiastical, but also the Civil Year, is still reckoned from the *Feast of the Annunciation*, or *Lady-Day*, as it was at first by *Dionysius* himself: Whereas in other Parts of *Christendom*, and even in *England* as to common Affairs which require not a Legal (Ecclesiastical or Civil) Date, the Year of Christ is reckoned now a-days not from the *Annunciation* or *Lady-Day*, but from the *Nativity* of Christ; which is now generally thought to have fell out, at the Winter-Solstice (not next after, but) next afore that *Annunciation*, which *Dionysius* made the Head of his *Æra*; and consequently to have fell out a few Days before the End of the 45th Year of the *Julian Epoch*; and so to have been a Year sooner than it is computed to have been according to the *Æra* of *Dionysius*, or the Account still used by the Church and State of *England* and *Ireland*.

There

Of the Year of the World.

63

There is also another *Æra* frequently made Use of by Christian Writers, namely, the *Æra* of the *Creation*, which is generally agreed to have been about 4000 Years before Christ. And because to say such or such a Thing fell out in such a Year of the *World*, does not give us so clear an Idea of the Distance of the said Occurrence from us, as it does to say, that it happened in such or such a Year *before Christ*; therefore, the Computation from the Creation of the World begins to be laid aside, even in Matters relating to the Sacred History of the Old Testament, and instead thereof the Occurrences of the Old Testament are now a-days computed by their Distance *before Christ*. Thus Instead of saying, that the *Universal Deluge* happened *A. M.* or in the Year of the *World*, 1656, it is thought more Instructive to say, that it happened 2294 Years *before Christ*, this last Manner of Computation giving us a clearer Notion of the Time when the Flood happened in respect of its Distance from us. For we being wont to reckon our Time *from Christ*, and so reckoning this present Year to be

3.
Of the
Æra of the
World, or
Creation.

be the 1711th from Christ; when we are told, that the Flood was 2294 before Christ, we can from thence easily gather, that the Flood was about 4000 Years ago in respect of this present Time. And on the same Considerations, it appears to be much the best or easiest and clearest Way for us to compute likewise all Occurrences mentioned in any other as well as the Sacred History, by their Distance either before or after Christ; and so to make the *Nativity of Christ* the Universal Head or Epoch of all Chronology, counting therefrom all Occurrences either *Backward* or *Forward*.

4.
Of the
Era of the
Olympi-
piads.

The most Antient and Renowned Epoch used by the Heathens is that of the *Olympiads* or *Olympick Games* which were instituted by one *Iphitus* in the Fields of *Olympia*, a City or Town of the Region *Elis* in the *Peloponnese*; and which lasted five Days the last whereof fell on the Full Moon which was next after the Summer Solstice. These Games were celebrated every four Years, *that is*, there were three Years between the Years when in the next preceding and the next following *Olympiad* was celebrated.

Her

Of the Olympiads.

65

Hence by a compleat *Olympiad*, is denoted the Space of four Years; the Year wherein the *Olympiad* was celebrated, being stiled the first Year of the said *Olympiad*, and so on. The Celebration of the first *Olympiad* is referred to the 3938th Year of the *Julian Period*; and consequently to the 777th Year *before Christ*, viz. to the Calends of *July*, in the Summer of the said Years. Wherefore,

Any Year of the *Olympiads* being given, to find the correspondent Year of the *Julian Period*, work thus: Multiply the compleat *Olympiads* by 4, and to the Product add the Year (if it be given) of the *Olympiad* running, and also 3937, the Sum is the Year of the *Julian Period* sought. For Instance, *Rome* is said to be built, according to *Varro's* Account, in the fourth Year of the sixth *Olympiad*. Wherefore I multiply 5 (the Number of the compleat *Olympiads*) by 4, which makes 20, and therefore I add more, (the Year given of the *Olympiad* running, or 6th *Olympiad*.) and also 3937. All which together amounts to 3961, the Year sought of the *Julian Period*.

5.
To find the Year of the *Julian Period* answering to any Year given of the *Olympiads*.

F

Having

6.
And there-
by to find
the corre-
spondent
Year of
Christ.

Having found the Year of the *Julian Period* answering to any given Year of the *Olympiads*, thereby may also be found the correspondent Year (respectively) before or after Christ. Namely, if the Year found of the *Julian Period* be less than 4713, then subtract the same from 4713, and the Remainder will shew the correspondent Year before Christ: but if the Year found of the *Julian Period* be greater than 4713, then subtract 4713 from it, and the Remainder will shew the correspondent Year after Christ. Thus, it being found, that Rome was built in *Julian Period* 3961, I subtract 3961 from 4713, and there remains 752, the correspondent Year before Christ, wherein Rome was built.

7.
Another
Way to find
the Year
of Christ
answering
to any
Olympick
Year.

But if there be no Occasion to find the correspondent Year of the *Julian Period*, the Year before or after Christ respectively answering to any given Year of the *Olympiads* may be found thus. Multiply (as afore) the compleat *Olympiads* by 4, and to the Product add the Year given (if any be specified) of the *Olympiad* running. This Sum, if it be less than 776, sub-

strac

tract it from 776, and the Remainder will shew the correspondent Year before Christ: but if the Sum be greater than 776, then subtract 776 from it, and the Remainder will shew the correspondent Year after Christ. Thus I would know what Year of Christ answers to the fourth Year of the sixth Olympiad, wherein Rome was built according to Varro. Wherefore, (as before) $5 \times 4 = 20$, and $20 + 4 = 24$. Which Sum being less than 776, I subtract it from 776, and there will remain 752, the correspondent Year before Christ, as was found before by the other Method.

Any Year of the Julian Period being given, to find what Olympick Year answers thereto, work thus: From the Year given subtract 3937, and divide the Remainder by 4, the Quotient will shew the compleat Olympiads, and the Fraction or Remainder of the Dividend will shew the Year of the Olympiad running. If there be no such Remainder, then it is the last or fourth Year of the Olympiad running.

8.
To find, what Olympick Year answers to any given Year of the Julian Period.

Ex. gr. I would know, what Olympick Year answers to J. P. 3961. From 3961, I subtract 3937, and

there remains 24 ; which divided by 4, gives 6 in the Quotient, and leaves no Fraction of the Dividend. Wherefore the *Olympick* Year sought, is the fourth Year of the sixth *Olympiad*,

9.
Of the
Æra of
U. C. or
the Building of
Rome.

As the Account by the *Olympiad* was, the principal *Æra* among the *Greeks* ; so the principal *Æra* among the *Romans* was, that of the (||) *U. C.* or *Building of Rome* ; which according to *Varro* began *Julian Period* 3961, but according to the *Festus Capitolini* in the following Year, viz. *Julian Period* 3962. Wherefore

10.
To find the
Year of the
Julian Period answering to
any given
Year of
U. C.

Any Year of *U. C.* being given add thereto 3960, and you'll have the correspondent Year of the *Julian Period*, according to *Varro's* Account or add 3961, and you'll have the correspondent Year of the *Julian Period*, according to the *Capitoline Account*.

On the contrary, from the given Year of *Julian Period*, subtract 3960 and the Residue will give the Year of *U. C.* according to *Varro* ; or subtract

(||) *U. C.* are the Initial Letters of *Urbs Condita* and so are put to denote in short the *Building of the City*, viz. *Rome*.

Subtract 3961, and the Residue will be the Year of U. C. according to the Capitoline Account.

Forasmuch as Rome is computed to have been built 752 Years before Christ; therefore from 752 subtract any given Year of U. C. less than the same, and the Residue will shew the correspondent Year before Christ: Or if the Year given of U. C. be greater than 752, then subtract 752 from it, and the Residue will shew the correspondent Year after Christ: Thus the Regal State of Rome is computed to have ended in U. C. 245, to which answers the Year 507 before Christ: for $752 - 245 = 507$. And the Removal of the Imperial Seat from Rome to Constantinople, by Constantine the Great is computed to have happened U. C. 1084, and so 332 Years after Christ: for $1084 - 752 = 332$.

As for other Epoch's or Æra's, they being of less Note and Use to us, it will be sufficient to shew in short, how long before or after Christ each of them began,

II.
To find the Year before or after Christ answering to any given Year of U. C.

12.
Of other Epoch's or Æra's.

Before Christ

The Destruction of Troy, }
 is computed to fall in with
 (*) Julian Period, 3531, } 1183.
 and so the Æra taken
 from thence to begin

The Æra of Nabonassar
 King of Babylon, from the
 Beginning of whose Reign
 the Chaldeans and Egypti- } 747.
 ans reckoned their Years,
 began February 26, J. P.
 3967, and consequently

The Æra (†) of the
 Death of Alexander the
 Great, began November 12, } 324.
 J. P. 4390, and so

(*) Herein is followed the Opinion of Dionysius Halicarnassensis, and Diodorus Siculus.

(†) Some distinguish between the Alexandrian Æra and the Philippean, making the Philippean (so called from Philip Aridaeus, Brother to Alexander the Great) to begin from the Death of Alexander, or more exactly from the 12th of November following the Death of Alexander, and so Julian Period, 4390; and the Alexandrian to begin not till twelve Years after Alexander's Death, viz. October 1st, Julian Period, 4402. This latter Æra is esteemed by some learned Men to be the same with the Æra Seleucidarum, otherwise called Æra Contractum, and the Years of the Greeks in the Books of the Maccabees.

Before Christ.

The Æra of the City
Antioch, used by Eusebius,
Eoagrius, Cedrenus, &c. be-
gan from the Autumn of
P. 4665, and so

49.

The Æra of the Julian
Reformation of the Calen-
dar, began January 1, J.
P. 4669, and so

45.

The Æra Afiaca, so
denominated from the Vi-
tory obtained by Augustus
over Anthony at Actium,
began August 29, J. P.
4684, and so

30.

After Christ.

The Dioclesian Æra, or
Æra of the (II) Martyrs,
otherwise called the Æra
of the Abissinians, began
August 29, A. D.

284.

(II) So called from the Multitude of Christians
that suffered Martyrdom in the Dioclesian Persecu-
tion.

After Christ

The Æra of the *Hegira*,
or Flight of *Mahomet* from
Mecca to *Medina*, used by
the *Turks* and *Arabs*, be- } 622.
gan July 16. A. D. }

The Æra of *Yezdegird*,
or the *Persian Æra*, began } 632.
July 16, A. D. }

From this Table of the Begin-
nings of the fore-mentioned Æra's
it is easy to find out the Year be-
fore or after Christ, which answer
to any Year given of any of the
said Æra's, which are computed by
Julian Years; as are the Æra's of
the Destruction of *Troy*, of the *Julian*
Reformation, of *Dioclesian*, &c.
But it is more difficult to do so
in respect of the Æra of *Nabonassar*,
of *Alexander's* Death, and of the
Hegira, because they are
computed by Years different from
the *Julian* Years. It will be suf-
ficient to our present Design to ob-
serve here, that 1461 *Nabonassar*
Year

Years, make only 1460 *Julian* Years;
and the same is to be understood
of the *Alexandrian* Years, as being
of the same Kind with the *Nabo-*
nassars.

CHAP.

C H A P. VII.

Of the Method to find Easter-Day, according to the Nicene Rule, (as still followed by our Church,) by the Help of the Golden Numbers affixed to the Calendar. To which is adjoined the Roman Method of Dating or denoting the Days of the Month.

I.
The Ni-
cene Rule
for finding
Easter-
Day.

THE Rule prescribed by the Fathers of the Nicene Council for the finding of Easter, and which is still followed by the Church of England, is thus expressed in our Common Prayer-Book: *Easter-Day is always the first Sunday after the first Full Moon which happens next after the One and Twentieth Day of March. And if the Full Moon happens upon a Sunday Easter-Day is the Sunday after.*

2.
To find
Easter-

According to this Rule, Easter-Day may easily be found by the Help of

Of finding Easter-Day.

75

the Golden Numbers (*) duly affixed to the Calendar, and by retaining in Memory, and applying to Practice, what has been said of the Golden Numbers, and Dominical Letter, *Chap.* 3d and 4th.

Day according to the said Rule, by the Help of the Golden Numbers.

For Instance, I would know, what Day *Easter-Day* will fall upon the next Year, *viz.* 1712. In order hereto, first I enquire what is the *Golden Number* for the given Year, and I find it to be three, according to the Rule given, *Chap. III. Sect. 6.* Then I enquire what is the Dominical or *Sunday Letter* for the given Year, and (according to the Rules given, *Chap. IV. Sect. 5. 6.*) I find that there will be two *Sunday Letters* next Year, it being Leap-Year. Of which two Letters, *viz.* *FE*, the latter *E* will be the *Sunday Letter* after *February 23d*, and so that whereby I am to be guided in finding out *Easter-Day*.

(*) In our old large Common Prayer-Books, great Care was taken duly to affix the Golden Numbers to their proper Days; and to that End black Lines were drawn between every Day of the Calendar. But of late Years no such Care is taken, insomuch that it is not to be known with any Certainty what Days the Golden Numbers do answer to in the Church-Calendars, of late printed without such black Lines.

Now

Now because the Full Moon, on which *Easter* depends, is (according to the *Nicene* Rule) that which happens next after the 21st of *March*; and because the said Full Moon is (agreeably to *Exod.* 12. 6.) to be esteemed the 14th Day after its New Moon inclusively, (*i. e.* the Day of the said New Moon, being reckoned the first of the 14th, and the Day of the Full Moon the last,) hence the said *Easter* New Moon can never fall before the 9th of *March*, nor after the 5th of *April*. Wherefore I look for the Golden Number 3 between *March* 9th, and *April* 5th, and find it placed to *March* 31st, which therefore was the Day on which the *Easter* New Moon fell at the Time of the *Nicene* Council, in the 3^d Year of the Moon's Cycle; and consequently esteemed so still by us. Wherefore the *Easter* Full Moon (being fourteen Days after inclusively) will be *April* 13th; which being shewn by the Letter E affix'd to it to be a *Sunday*, therefore, by the *Nicene* Rule, *Easter*-Day must be the *Sunday* after, *viz.* *April* 20th. And in like manner may

Easter

Easter-Day be found for any other given Year, by the Help of the Calendar adjoined to the End of this Chapter, and consequently Tables may be made, shewing the Day, whereon *Easter* will fall, for any Term of Years.

It remains now only to observe, that in Order to render the following Calendar more useful, therein is set down the *Roman Manner of Dating*, or denoting the several Days of the Year. Where it is to be noted, that the *Roman Numbers* between the Words *Kalends*, *Nones*, *Ides* and *Calends* of the succeeding Month, do respectively refer always to the following Word. Thus the Number IV over-against *January 2d*, refers to the following *Nones*, and denotes as much as the 4th Day of, or before the *Nones* of *January*. So XI set to *January 22d*, denotes the 11th of, or before the *Calends* of *February*.

Wherefore any *Roman Date* given, may be turned into *our Date*, by finding in the Calendar the Date given, (suppose 3 *Id. Februar.*) and seeing

3.
Of the Ro-
man Way
of Dating,
or denoting
the Days of
the Year.

seeing what Date of ours answer
thereto, (*viz.* February 11th.) And on
the other Hand any Date of ours
being given, *v. g.* January 31st; it
may be turned into the Roman Date
by finding the Roman Date affixed
thereto, *viz.* Prid. Kal. Febr.

January

The Calendar

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January.

February.

Golden Number.	Day of Month.	Letters.	Weekly	Roman Date.	Golden Number.	Day of Month.	Letters.	Weekly	Roman Date.
3	1	A		Calendæ	11	1	D		Calendæ
	2	B		IV	19	2	E		IV
1	3	C		III	8	3	F		III
	4	D		Prid.		4	G		Prid.
9	5	E		Nonæ	16	5	A		Nonæ
8	6	F		VIII	5	6	B		VIII
	7	G		VII		7	C		VII
6	8	A		VI	13	8	D		VI
5	9	B		V	2	9	E		V
	10	C		IV		10	F		IV
3	11	D		III	10	11	G		III
2	12	E		Prid.		12	A		Prid.
	13	F		Idus.	18	13	B		Idus.
10	14	G		XIX	7	14	C		XVI
9	15	A		XVIII		15	D		XV
8	16	B		XVII	15	16	E		XIV
	17	C		XVI	4	17	F		XIII
7	18	D		XV		18	G		XII
6	19	E		XIV	12	19	A		XI
5	20	F		XIII	1	20	B		X
	21	G		XII		21	C		IX
3	22	A		XI	9	22	D		VIII
2	23	B		X		23	E		VII
	24	C		IX	17	24	F		VI
10	25	D		VIII	6	25	G		V
9	26	E		VII		26	A		IV
8	27	F		VI	14	27	B		III
	28	G		V		28	C		Prid. Kal.
6	29	A		IV					
5	30	B		III					
3	31	C		Prid. Kal.					

Golden

March.					April.				
Golden Number.	Day of Month.	Letters Weekly	Roman Date.		Golden Number.	Day of Month.	Letters Weekly	Roman Date.	
3 . .	1	D	Calendæ			1	G	Calendæ	
	2	E	VI		11 . .	2	A	IV	
11 . .	3	F	V			3	B	III	
	4	G	IV		19 . .	4	C	Prid.	
19 . .	5	A	III		8 . .	5	D	Nonæ	
8 . .	6	B	Prid.		16 . .	6	E	VIII	
	7	C	Nonæ		5 . .	7	F	VII	
16 . .	8	D	VIII			8	G	VI	
5 . .	9	E	VII		13 . .	9	A	V	
	10	F	VI		2 . .	10	B	IV	
13 . .	11	G	V			11	C	III	
2 . .	12	A	IV		10 . .	12	D	Prid.	
	13	B	III			13	E	Idus.	
10 . .	14	C	Prid.		18 . .	14	F	XVIII	
	15	D	Idus.		7 . .	15	G	XVII	
18 . .	16	E	XVII			16	A	XVI	
	17	F	XVI		15 . .	17	B	XV	
	18	G	XV		4 . .	18	C	XIV	
15 . .	19	A	XIV			19	D	XIII	
4 . .	20	B	XIII		12 . .	20	E	XII	
	21	C	XII		1 . .	21	F	XI	
12 . .	22	D	XI			22	G	X	
1 . .	23	E	X		9 . .	23	A	IX	
	24	F	IX			24	B	VIII	
9 . .	25	G	VIII		17 . .	25	C	VII	
	26	A	VII		6 . .	26	D	VI	
17 . .	27	B	VI			27	E	V	
6 . .	28	C	V		14 . .	28	F	IV	
	29	D	IV		3 . .	29	G	III	
14 . .	30	E	III			30	A	Prid.	
3 . .	31	F	Prid. Kal.						

The Calendar

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May

June

Golden Number.	Month.	Day of	Letters.	Week.	Roman Date.
		1	A	I	Calends
		2	B	II	VI
		3	C	III	V
		4	D	IV	IV
		5	E	V	III
		6	F	VI	Prid.
		7	G	VII	Nonæ
		8	A	III	VIII
		9	B	IV	VII
		10	C	V	VI
		11	D	VI	V
		12	E	VII	IV
		13	F	VIII	III
		14	G	IX	Prid.
		15	A	X	Idus.
		16	B	XI	XVII
		17	C	XII	XVI
		18	D	XIII	XV
		19	E	XIV	XIV
		20	F	XV	XIII
		21	G	XVI	XII
		22	A	XVII	XI
		23	B	XVIII	X
		24	C	XIX	IX
		25	D	XX	VIII
		26	E	XXI	VII
		27	F	XXII	VI
		28	G	XXIII	V
		29	A	XXIV	IV
		30	B	XXV	III
		31	C	XXVI	Prid. Kal.

Golden Number.	Month.	Day of	Letters.	Week.	Roman Date.
		1	A	I	Calends
		2	B	II	IV
		3	C	III	III
		4	D	IV	Prid.
		5	E	V	Nonæ
		6	F	VI	VIII
		7	G	VII	VII
		8	A	VIII	VI
		9	B	IX	V
		10	C	X	IV
		11	D	XI	III
		12	E	XII	Prid.
		13	F	XIII	Idus.
		14	G	XIV	XVIII
		15	A	XV	XVII
		16	B	XVI	XVI
		17	C	XVII	XV
		18	D	XVIII	XIV
		19	E	XIX	XIII
		20	F	XX	XII
		21	G	XXI	XI
		22	A	XXII	X
		23	B	XXIII	IX
		24	C	XXIV	VIII
		25	D	XXV	VII
		26	E	XXVI	VI
		27	F	XXVII	V
		28	G	XXVIII	IV
		29	A	XXIX	III
		30	B	XXX	Prid. Kal.

G

Golden

July.					August.				
Golden Number.	Month.	Day of	Weekly Letters.	Roman Date.	Golden Number.	Month.	Day of	Weekly Letters.	Roman Date.
19 ..		1	G	Calendæ	8 ..		1	G	Calendæ
8 ..		2	A	VI	16 ..		2	D	IV
		3	B	V	5 ..		3	E	III
16 ..		4	C	IV			4	F	Prid.
5 ..		5	D	III	13 ..		5	G	Nonæ
		6	E	Prid.	2 ..		6	A	VIII
13 ..		7	F	Nonæ			7	B	VII
2 ..		8	G	VIII	10 ..		8	C	VI
		9	A	VII			9	D	V
10 ..		10	B	VI	18 ..		10	E	IV
		11	C	V	7 ..		11	F	III
18 ..		12	D	IV			12	G	Prid.
7 ..		13	E	III	15 ..		13	A	Idus.
		14	F	Prid.	4 ..		14	B	XIX
15 ..		15	G	Idus.			15	C	XVIII
4 ..		16	A	XVII	12 ..		16	D	XVII
		17	B	XVI	1 ..		17	E	XVI
12 ..		18	C	XV			18	F	XV
1 ..		19	D	XIV	9 ..		19	G	XIV
		20	E	XIII			20	A	XIII
9 ..		21	F	XII	17 ..		21	B	XII
		22	G	XI	6 ..		22	C	XI
17 ..		23	A	X			23	D	X
6 ..		24	B	IX	14 ..		24	E	IX
		25	C	VIII	3 ..		25	F	VIII
14 ..		26	D	VII			26	G	VII
3 ..		27	E	VI	11 ..		27	A	VI
		28	F	V			28	B	V
11 ..		29	G	IV	19 ..		29	C	IV
		30	A	III	8 ..		30	D	III
19 ..		31	B	Prid. Kal.			31	E	Prid. Kal.

The Calendar.

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September.				October.			
Golden Number.	Day of Month.	Weekly Letters.	Roman Date.	Golden Number.	Day of Month.	Weekly Letters.	Roman Date.
16 . .	1	F	Calendæ	16 . .	1	A	Calendæ
5 . .	2	G	IV	5 . .	2	B	VI
	3	A	III	13 . .	3	C	V
13 . .	4	B	Prid.	2 . .	4	D	IV
2 . .	5	C	Nonæ		5	E	III
	6	D	VIII	10 . .	6	F	Prid.
10 . .	7	E	VII		7	G	Nonæ
	8	F	VI	18 . .	8	A	VIII
18 . .	9	G	V	7 . .	9	B	VII
7 . .	10	A	IV		10	C	VI
	11	B	III	15 . .	11	D	V
15 . .	12	C	Prid.	4 . .	12	E	IV
4 . .	13	D	Idus.		13	F	III
	14	E	XV II	12 . .	14	G	Prid.
12 . .	15	F	XVII	1 . .	15	A	Idus.
1 . .	16	G	XVI		16	B	XVII
	17	A	XV	9 . .	17	C	XVI
9 . .	18	B	XIV		18	D	XV
	19	C	XIII	17 . .	19	E	XIV
17 . .	20	D	XII	6 . .	20	F	XIII
6 . .	21	E	XI		21	G	XII
	22	F	X	14 . .	22	A	XI
14 . .	23	G	IX	3 . .	23	B	X
3 . .	24	A	VIII		24	C	IX
	25	B	VII	11 . .	25	D	VIII
11 . .	26	C	VI		26	E	VII
19 . .	27	D	V	19 . .	27	F	VI
	28	E	IV	8 . .	28	G	V
8 . .	29	F	III		29	A	IV
	30	G	Prid. Kal.	16 . .	30	B	III
				5 . .	31	C	Prid. Kal.
							Golden

G 2

November.				December.			
Golden Number.	Month.	Day of the Week.	Roman Date.	Golden Number.	Month.	Day of the Week.	Roman Date.
		1 D	Calendæ	13 .		1 F	Calend
13 .		2 E	IV	2 .		2 G	IV
2 .		3 F	III			3 A	III
		4 G	Prid.	10 .		4 B	Prid.
10 .		5 A	Nonæ			5 C	Nonæ
		6 B	VIII	18 .		6 D	VIII
18 .		7 C	VII	7 .		7 E	VII
7 .		8 D	VI			8 F	VI
		9 E	V	15 .		9 G	V
15 .		10 F	IV	4 .		10 A	IV
4 .		11 G	III			11 B	III
		12 A	Prid.	12 .		12 C	Prid.
12 .		13 B	Idus.	1 .		13 D	Idus.
1 .		14 C	XVIII			14 E	XIX.
		15 D	XVII	9 .		15 F	XVIII
9 .		16 E	XVI			16 G	XVII
		17 F	XV	17 .		17 A	XVI
17 .		18 G	XIV	6 .		18 B	XV
6 .		19 A	XIII			19 C	XIV
		20 B	XII	14 .		20 D	XIII
14 .		21 C	XI	3 .		21 E	XII
3 .		22 D	X			22 F	XI
		23 E	IX	11 .		23 G	X
11 .		24 F	VIII			24 A	IX
19 .		25 G	VII	19 .		25 B	VIII
		26 A	VI	8 .		26 C	VII
8 .		27 B	V			27 D	VI
		28 C	IV	16 .		28 E	V
16 .		29 D	III	5 .		29 F	IV
5 .		30 E	Prid. Kal.			30 G	III
				13 .		31 A	Prid. Kal.

Of finding Easter-Day.

85

Having shewn how to find *Easter-Day* according to the *Julian* or Old Account, used by Us in *Great Britain* and *Ireland*, it may not be improper to adjoin here, by way of Annotation, the Method of finding *Easter-Day* according to the *Gregorian* or New Account, used in all Countries where the *Popish* Religion is established. Now this is done by Help of the Table here subjoined, wherein in the first Column are contained the *Gregorian* Epacts, that are now and will be in Use till 1800 exclusively; and in the second Column are set down the Days whereon falls the *Easter* Full Moon; and in the third Column is set down the Weekly Letter answering to the said Days of the *Easter* Full Moon.

Epacts.	Full Moons.	Weekly Letters.	Epacts.	Full Moons.	Weekly Letters.
X	13 April	E	IX	4 April	C
XI	2 April	A	XX	24 March	F
XXII	22 March	D	I	12 April	D
III	10 April	B	XII	1 April	G
XIV	30 March	E	XXIII	21 March	C
XXV	18 April	C	IV	9 April	A
VI	7 April	F	XV	29 March	D
XVII	27 March	B	XXVI	17 April	B
XXVIII	15 April	G	VII	6 April	E
			XVIII	26 March	A

The

Of finding Easter-Day.

The Use of the foregoing Table is this. Having found (as is above shewn in the Note on *Chap. 3. Sect. 8.* and *Chap. 4. Sect. 7.*) the *Gregorian Epact* and *Sunday-Letter*, over-against the said *Epact* in the foregoing Table is placed the Day whereon falls the *Easter Full Moon*, and thereto is affixed its respective Letter. From which therefore you are to reckon in an Alphabetical Order, till you come to the *Sunday-Letter* for that Year, and the Day of the Month answering to the said *Sunday-Letter* is the *Gregorian Easter-Day*. Only if it happens, that the Full Moon falls on a *Sunday*, then (according to the *Nicene Rule*) the *Sunday* next following is the *Gregorian Easter-Day*. For Instance: It has been already (*viz.* in Notes on *Chap. 3. Sect. 8.* and *Chap. 4. Sect. 7.*) found, that the *Gregorian Epact* for A. D. 1712 is 22, and that the *Gregorian Sunday-Letters* are CB, *viz.* C to the intercalated Day in *February*, and after that B; which last Letter B is therefore the *Sunday-Letter*, whereby you are to be guided in finding *Easter-Day*. Now by the foregoing Table you learn, that when the *Gregorian Epact* is 22, the *Easter Full Moon* according to the *Gregorian Account* will fall on *March 22d*, N. S. (*i. e.* *March 11th*, O. S.) to which answers the Letter D, as may be seen in the foregoing Calendar. Wherefore reckoning in an Alphabetical Order from D to B, which last is the *Gregorian Sunday-Letter*, you'll find, that according to the *Gregorian Computation*, *Easter-Sunday* will be *March 27th*, N. S. which answers to our *March 16th*; and consequently, the *Gregorian Easter-Day* will fall A. D. 1712, five Weeks before our *Easter-Day*, this falling on *April 20th*, as has been afore shewn.

It only remains to observe in short, that it having been shewn, how to find both the *Julian* and *Gregorian Easter-Day*, thereby may be known the Time of all the *Movable Festivals* in any given Year; forasmuch as they all depend on *Easter-Day*. And consequently hereby, and by what has been said of finding the Days whereon fall the New and Full Moons,

Moons, may be drawn up an Almanack sufficient for common Use. And thus I have laid together so much of Chronology, as seems requisite to be known by Young Gentlemen, at least at their first Institution in the said Art or Science.

F I N I S.

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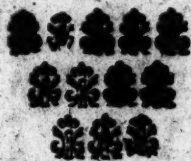
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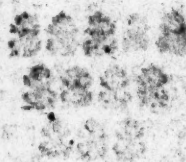


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The Preface.

Gentleman's Dialling
be learnt from the Preface to

~~the Young Gentleman's~~

contained in like manner.

THE

YOUNG GENTLEMAN'S

PREFACE.

As the Dependence of

the Art of Dial-

ling upon Astrono-

my, was the Reason of my

Drawing up and Publishing

this Treatise, at the same

Time with my Astronomical

Treatise; so my Design in

drawing up this Treatise, and

the Reason of my giving it

the Title of The Young

(A 2) Gen-

The Preface.

Gentleman's Dialling, may be learnt from the Preface to my Treatise of Astronomy entituled in like manner The Young Gentleman's Astronomy. I need only observe further, that I have not contented my self with laying down in this Treatise the bare Practical Part of Dialling, but have added thereunto the Reasons or Grounds of such Practice, as most proper to be known by Young Gentlemen; and withal have observed, in the Annotations to this Treatise, how the Grounds of Dialling may be most naturally represented even to the Eye, by the Help

The Preface.

Help of a Machine or Instrument, which from its Use may be called a Dialling Sphere.

THE

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CHAP. III.

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CHAP. IV.

The Preface.
Help of a Machine or In-
strument, which from its
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43

THE Young Gentleman's DIALLING, &c.

CHAP. I.

Of Dialling in general.

BY (*) *Dialling* is understood i.
Dialling,
what.
the Art of Shewing the Time
of the Day, by the Sun's
Shade falling on some Sur-
face, whether Plain or not Plain.

(*) The Word *Dial* is derived from *Dier*, because
thereupon the Time of the Day is shewn. And from
the peculiar Manner of shewing the Time of the Day
on a Dial, viz. by the Shadow of the Sun, this Art
is frequently termed *Ars Scioferica*; i. e. the Shadow-
art, from the Greek Word *σκιαν*, denoting a Shadow,
or Shade.

(B) Plain

Of Dialling.

2. Plain Surfaces are most useful, and therefore most used : for which Reasons we shall here speak only of *Plain-Dialling*, i. e. of drawing Dials on Plain Surfaces, simply called *Planes*.

3. Every Dial-plane (i. e. Plain Surface, on which a Dial is drawn) represents the Plane of some (†) Circle in the Heavens. If the Dial-plane represents

The various Names of Dials, and the Reason of the said Names.

(†) This, and the whole Foundation of Dialling is most naturally, and so most clearly, illustrated by the Help of an Instrument or Machine, which may be properly enough called from its Use a *Dialling Sphere*. It need consist but of an *Horizon*, and two (Wooden or Brass) Circles fastened together, crossing each other at Right Angles, and so as to bisect one the other. Either of these Circles may be taken to represent the *Meridian*, and the other the *Aequator*. The former is to be divided into four 90 Degrees, and the latter into 360, as in other Spheres or Globes. And in like manner, as in other Spheres, the *Meridian* of this Dialling Sphere must be let into the *Horizon* at the North and South Points of it. There must be a plain Piece of Board to move up and down within the fore-mentioned Circles, so as to represent the Position of any Dial-plane. And through the Center or middle Point of the plain Piece of Board, there must be made an Hole, through which, when there is occasion, a String is to be put; which String being put through the two Points of the *Meridian*, which are 90 Degrees each from the *Aequator*, will represent the Axis of the World. The Dialling Sphere being thus prepared, the Manner how the Sun, by the Shadow of the Style of the Dial, comes to shew the Time of the Day on any Dial-plane, may be ocularly demonstrated.

represents the Plane of the *Horizon*, the Dial is called an *Horizontal* Dial. If the Dial-plane represents the Plane of the *Prime Vertical*, then the Dial is called an *Erect Direct North* or *South* Dial, respectively as the Dial is drawn on the north or south Side of the said Dial-plane. If the Dial-plane represents the Plane of the *Meridian*, the Dial is called an *Erect Direct East* or *West* Dial, respectively as the Dial is drawn on the east or west Side of such a Dial-plane. If the Dial-plane represents the Plane of any other Vertical Circle, besides the *Prime Vertical* and *Meridian*, then the Dial is called a *Declining* Dial; forasmuch as it does not directly face any one of the four Cardinal

illustrated, by moving the *Meridian* of the Dialling Sphere, that the String representing the Axis, may have such a Position as duly answers to the Latitude of the Dial; and by placing the plain Piece of Board in such a Position as to answer (the Plane of that Circle in the Heavens, which is represented by the Dial-plane; or in short, to answer) the Position of the Dial-plane. Then a Candle duly moved round the String in Imitation of the Sun's Motion, will shew by the Shade of the String, how the Shade of the Dial-Style by the Motion of the Sun, shews the Time of the Day on the Dial-plane.

(B 2)

Points

Points of the Heavens, but decline more or less from them. Lastly, if the Dial-plane represents the Plane of any greater Circle in the Heavens besides some Vertical Circle or the *Horizon*, then the Dial is called (not an Erect, but) an (*||*) *Inclining* or *Reclining* Dial, respectively as it is drawn, either on that Side of the Dial-plane, which inclines (or leans forward) towards the *Horizon*; or on the other Side, which reclines (or leans backward) from the *Zenith*. And amongst these are the (*) *Equinoctial*

(*||*) These are subdivided into *Direct* Incliners or Recliners, and *Declining* Incliners or Recliners.

(*) The *Equinoctial* Dial is Erect in respect of the who live exactly under the *Celestial Equator*; and likewise the *Polar* Dial is Erect to such as live (if any there be) exactly under either of the two Poles of the World. For in respect of the former Inhabitants, the Plane of the *Equinoctial*, and of the Prime Vertical are one and the same; and in respect of the latter Inhabitants, the Plane of the Prime Vertical, and the Plane of the Circle represented by the Plane of a *Polar* Dial is one and the same. Again, the *Equinoctial* Plane is the same with the *Horizontal* Plane in respect of the that are under the Poles; and the *Polar* Plane is the same with the *Horizontal* Plane, in respect of the that live under the *Equator*. And the like Change is to be conceived in respect of other Dial-planes, they regard several Places; every Dial-plane being a *Horizontal* Plane at some Place, and on the other Side every *Horizontal* Plane being a Prime Vertical, and a *Meridian* (&c.) Plane at some other Places.

not

(†) The
Polar Di
therefore
this Tre

Of Dialling.

5

Equinoctial and *Polar* Dials. The *Equinoctial* Dial is so called, as being drawn on a Plane, that represents the Plane of the *Equinoctial*. The *Polar* Dial is so called, as being drawn on a Plane, that represents the Plane of that Circle, which passes through the Poles of the World, and also (the Intersection of the *Equator*, and the *Horizon* at the east and west Points, i. e. in short) the Poles of the *Meridian*.

Among the several Sorts of Dials,

4.

fore-mentioned, the *Equinoctial* Dial, Of the Equinoctial Dial.

is the most easy to be drawn; this being done only by drawing a Circle, and dividing it into twenty-four equal parts, (to which right Lines drawn from the Center of the Circle, will represent the several Hour-Lines,) and erecting perpendicularly a Pin in the Center of the Circle for the Style. That because (†) the *Equinoctial* Dial, when thus drawn on one Surface of the Plane, will serve only for one

(†) The like is to be understood also as to the *Polar* Dial; on which Account it is of lesser Use, and therefore the Manner of describing it is omitted in this Treatise.

Half of the Year, namely, whilst the Sun is on one Side of the *Equinoctial* and therefore to make it serve for the whole Year, it must be doubly drawn viz. on the lower as well as upper Side of the Plane; on Account of this and other Inconveniencies, the *Equinoctial* Dial is seldom used. And therefore it had not been taken Notice of here, but that the Knowledge thereof is requisite for the Understanding the Reason of that Method which (as being the most Natural, and withal easy Method) is principally made Use of in this Treatise, for drawing the other Dials here spoken of. For, as the Reason why the Circle in an *Equinoctial* Dial is divided into twenty-four equal Parts, answering to the twenty-four Hours of a *Nuchthemeron*, is because 15 Degrees, which is a 24th Part of the *Equinoctial*. Circle in the Heaven answer to one Hour's Motion of the Sun; so, because (at the same Time that the Sun is conceived, by the Shade of the Axis of the World, to shew any Hour on the *Equinoctial* Plane, it does also by the same Shade shew, at the Intersection of any other Plane

Of Dialling.

3

Plane with the *Equinoctial* Plane, the Point of the said other Plane belonging to the same Hour; or thus, because) the Hour-points of any other Plane are these Points of the said Plane, which fall in with or touch the Hour-points of the *Equinoctial* Plane, at the common Intersection of the said two Planes; therefore by the Help of the *Equinoctial* Dial may be drawn other Dials, namely, the *Equinoctial* Dial being duly applied to the Plane given, the Hour-points of the *Equinoctial* Dial will fall on the correspondent Hour-points of (the Dial to be drawn on the) Plane given.

And this will be distinctly exemplified as to the several Sorts of Dials above-mentioned, (excepting Inclining and Reclining Dials, as being of lesser Use) after that it has been here observed further in general, that the whole Business of Dialling may be reduced to three general Heads or Operations. Whereof the first consists in finding the Place of the *Substyle*, or where the *Style* is to be placed: the second in drawing the *Hour Lines*: the third and last, either, if the Dial-plane be Moveable, in duly

(B 4) ~~Placing~~

5.
The Business of
Dialling reducible
to three general
Heads or Operations.

Placing and *Fixing* the same, after that the Dial is drawn thereon; or else; if the Plane whereon the Dial is to be drawn, be unmovable and already fixed; in Finding the *Position* or Situation of the said Plane, viz. whether it be a Direct or Declining Plane; and if the latter, how far it declines.

CHAP.

Of an Horizontal Dial.

9

C H A P. II.

Of an Horizontal Dial.

I Begin with the *Horizontal Dial*, as being the most Useful; forasmuch as it singly answers the whole (*) End of Dialling, by shewing the Time of the Day from Sun-rising to Sun setting throughout the whole Year, within that *Horizon* for which it is made: whereas no other Dial does this. And having made this Observation as to the Usefulness of the *Horizontal Dial*, we proceed now to the Delineation thereof.

Whereas the four Cardinal Points of the Heavens are distant one from the other 90 Degrees; and whereas the *Meridian* runs from North to South, and the *Prime Vertical* runs a-cross the *Meridian* from East to

I.

The Horizontal Dial why first spoken of.

2.

To draw the Meridian and Prime Vertical Lines of an Horizontal Dial.

(*) The whole proper End of Dialling is, to shew the Time of the Day by the Sun's Shade. As for shewing the Place of the Sun in the Ecliptick (and the like) by the Shade on a Dial-plane, this does not properly belong to Dialling,

West;

West; hence it follows, that, two right Lines being drawn, crossing one the other at right Angles (whose Measure is each 90 Degrees) and either of these two right Lines being taken to represent the *Meridian*, the other will represent the *Prime Vertical*. That taken to represent the *Meridian*, may be fitly denoted by N S, as running in this Dial from North to South; the other by E W, as running from East to West. See Fig. 1.

3.
The Center of an Horizontal Dial, which.

The Point, where the Lines N S and E W cross one another, denotes (+) that Point in the Plane of the *Horizon*, (as also of the *Meridian* and *Prime Vertical*) through which the Axis of the World passes. And because the said Point is the (||) Center (of all the said Planes, parti-

(+) This may be evidently shewn by the Help of a Dialling Sphere.

(||) The Axis of the World passing through the Center of the World, which is also the Center of all great Circles in the Heavens, and consequently of the *Horizon*, *Meridian*, and *Prime Vertical*; hence it follows, that That Point in the Planes of the said Circles through which the Axis of the World passes, must be the Center of the said Planes.

cularly)

Of an Horizontal Dial.

11

cularly) of the *Horizontal Plane*, whereon the Dial is to be drawn, and consequently the Center of the Dial is self, hence it may be fitly marked or denoted by C, as *Fig. 1.*

The Axis of the World being the (*) common Intersection of the Planes of all *Meridians*, and therefore running from Pole to Pole along the Plane of every *Meridian*; hence the Line N S representing the Plane of the *Meridian* of that Place, for which the Dial is made, must be the *Substyle*, or the Line whereon the (†) *Style*, which represents the Axis of the World, is to be (||) erected.

4.
Of the Sub-
style and
Style.

(*) This may also be evidently shewn by the Help of the Dialling Sphere.

(†) It is so called, because it needs be, and often actually is, no more than a long straight Iron Pin, like an Engraving or old Sort of writing Pin, called a *Style*. It is called also by a *Latin Word*, the *Index*, because it tells or *shews* what is the Time of the Day. And it is called likewise by a *Greek Word* the *Gnomon*, (from γνῶω to know) because thereby is known the Time of the Day.

(||) By being *erected* is understood here, and all along this Tract of Dialling, being placed *perpendicularly* upon the *Substyle*, so as not to lean any Thing more towards the Hour-lines on one Side of the *Substyle*, than towards the Hour-lines on the other Side of the *Substyle*.

And

And because the Style does represent the Axis of the World, therefore it must be so erected upon the Substyle, (which is the common Intersection of the *Horizontal* and *Meridian* Planes) as therewith to make an Angle equal to the Elevation of the respective (North or South) Pole above the *Horizon* of the Place, or (which comes to the same) to the (*) Latitude of the Place. Wherefore taking C for the Center, draw (†) an Arch of a Circle from N S. (on either Side) to E W. On the said Arch (||) fet off from N S towards E W, (*viz* at P, *Fig.*

(*) How the Elevation of the Pole and Latitude of the Place come to be always Equal, may be evidently shewn on the Globe.

(†) This Arch may be drawn, at what Extent of the Compasses or Distance from the Center you please; but it is convenient to have regard to the Largeness of the designed Dial. And also it is convenient to make Use of a *Line of Chords*, in this, and all such Operations, in Order to the setting off on the Arch drawn any Number of Degrees, with much more Ease and Readiness than can be done otherwise. The Reader is here supposed to be already instructed in the Use of the *Line of Chords*.

(||) That is, the Style, if it be only a long straight Piece of Iron must be so placed on the Substyle of the Dial, as to have the same Inclination thereto, as CP has

1.) so many Degrees as answer to the Elevation of the Pole; for Instance (Fig. 1.) $51\frac{1}{2}$ the Latitude of London, or Elevation of the north Pole there. The Line CP being drawn will shew the Style.

Having found the Substyle NS, and the Style CP, draw a long Line crossing the Substyle in any Point, (which shall seem most convenient,) suppose Q, at right Angles. This Line representing the common Intersection of the Equinoctial Plane and Dial Plane, is therefore called the (*) *Contingent Line*, and is denoted (Fig. 1.) by the Line TG. That Point in the Substyle, which is so far distant from Q, as the Point Q is found by the Compasses to be distant from the nearest Point of the Style, represents the Center of the *Equator*,

5.
of the
Contingent Line,
and applying the
Equinoctial Dial to
the Plane
of your
Horizontal
Dial.

has to N S. If you would have the Style a broad Plate of Iron or the like, then it must be made exactly equal to the Triangle SCP. In both Cases, the lower Point of the Style, namely, wherein the Lines CS and CP meet, must be placed exactly on C, as being the Point of the *Horizontal Plane*, through which passes the Axis, represented by the Style.

(*) It is so called, because herein the two Planes are conceived to touch one another.

OR

or that Point from which an *Equinoctial* Dial is to be delineated on the Dial-plane, and therefore it may fitly be marked *Æ*. Taking then *Æ* for the Center, at (†) any Distance, draw toward the Contingent a (||) Semicircle representing half the *Equinoctial*, so as that one Half of the Semicircle (*i. e.* fourth Part of the *Equinoctial*) may be on each Side of the Substyle. Then divide the said Semicircle into twelve equal Parts, (*viz.* six on each Side of the Substyle,) each containing an Arch of 15 Degrees. (*) Lines drawn from *Æ* the

(†) However it is convenient to be guided herein by the Length of the Line of Chords made use of, and by the Size of the intended Dial.

(||) This may be otherwise done by only drawing one Half of this Semicircle on one Side of the Substyle, and dividing it into six equal Parts; and thence transferring the said six Divisions to that Part of the Contingent, which is on the other Side of the Substyle. And this is the best Way for practice, being shorter, and not cumbring the Work with Multitude of Lines. And 'tis adviseable to draw the said Quadrant, or fourth Part of the *Equinoctial* Circle, or Dial on that Side of the Substyle, where the Style is not drawn: because then the *Equinoctial* Dial, and the Style will stand both clear one from the other, as in the Figures hereunto belonging.

(*) These, and all other Lines or Circles or Arches of Circles are to be *obscure* ones, *i. e.* such as may be rubbed out again, excepting only the proper Hour-lines

At the Center of the *Equinoctial* to each Division of the Semicircle will be the Hour Lines of the *Equinoctial* Plane or Dial; among which Hour Lines, the *Substyle* and *Meridian* NS of the *Horizontal* Dial will also be the *Meridian* of the *Equinoctial* Dial.

Having thus fitted the *Equinoctial* Dial to the *Horizontal* Plane, on which the *Horizontal* Dial is to be drawn, it will be very easy to find the Hour-points of the said *Horizontal* Dial: namely, by continuing the *Equinoctial* Hour-lines to the Contingent, and thereby seeing, on what Points of the *Horizontal* Plane the Hour-lines of the *Equinoctial* Plane will fall. For the said Points of the *Horizontal* Plane are respectively the Points, on which the correspondent Hour-lines of the *Horizontal* Dial will fall, being drawn from (†) C the Center of the *Horizontal* Dial. Among

6.
To draw
the Hour-
lines of an
Horizontal
Dial.

lines in each Dial. These obscure Lines are distinguished in the Draughts hereunto belonging by being made prick'd Lines.

(†) The Hour-lines represent the Shade conceived to be made by the Axis of the World; which Axis being

mong these Hour-lines, the Line NS, being both the *Meridian* and Substyle of the *Horizontal Dial*, (and so falling in with the *Meridian* of the *Equinoctial Dial*) will therefore be the twelve a Clock Line of the *Horizontal* (as well as *Equinoctial*) Dial. Which being known, the Numbers 11, 10, 9, 8, and 7, are to be affixed to the Hour-lines on the west Side of the Dial, according to their respective Order from the twelve a Clock Line. And in like manner the Numbers, 1, 2, 3, 4, and 5, are to be set to the respective Hour-lines on the east Side of the Dial. The Line EW, as representing the Prime Vertical, is always the 6 a Clock Line, both Morning

being conceived to pass through C the Center of the Dial, hence all the Hour-lines must be drawn from the said Center. Only it is observable, that it is more Ornamental, not to draw actually the Hour-lines from C (because if they were so drawn, they would be apt to run together, and blot at the point C,) but making a Circle at some small distance from C, actually to draw the Hour-lines only from the said Circle, by the Ruler duly applied to C, as *Fig. 1.* 'Tis also observable, that the Dial-plane may be of any Shape, *viz.* Round or Triangular, &c. as well as Square or Oblong, though this Shape is most used among us.

and

and Evening. And as for the Hours before six in the Morning, and after six in the Evening, their Lines are drawn by continuing the Lines of those Hours, which are of the same Denomination in the contrary Part of the Day, through the Center C of the Dial. Thus the Hour-lines of 5 and 4 in the Morning are drawn, by continuing the Hour-lines of 5 and 4 in the Afternoon through C. And the Hour-lines of 7 and 8 in the Evening are drawn, by continuing the Hour-lines of 7 and 8 in the Morning thro' C. And thus the Delineation of an *Horizontal* Dial is finished, (as is represented, *Fig. 1.*) according to the Method of Delineating the same by the Help of an *Equinoctial* Dial. For as to the intermediate Spaces between each Hour, (*viz.* Quarter, Half, and three Quarters,) they are had by dividing the Space between each two Hours, first into Half, and each Half again into Quarters.

(C)

It

7.
To draw
an Hori-
zontal
Dial by a
Dialling
Scale.

It may not be unuseful (not only for Variety, (†) but also Proof sake) to add here the Method of drawing an *Horizontal Dial*, by Dialling Scales and Tables. The former is thus: The Lines NS and EW being drawn, and the Style CP erected, as afore; the Length of the Line EW is to be determined, so as to bear a due Proportion to the Scale of Hours you are to Use. This is done by placing one Foot of the Compasses at the Beginning of the Scale of *Latitudes*, (contained in the Dialling Scale,) and opening the other Foot, till it reaches to the Number of Degrees in the said Scale of Latitude, which answers to the Latitude of the Place. This Extent is to be set off on the Line EW from C towards E, and also towards W; and where it Ends, it may be respectively marked e, w, as Fig. 2

(†) If you have drawn your Dials right, the same Hour-lines, at equal Distance from the Center of your Dial, will be equally distant also one from the other by which Method soever you draw them. v. g. The Distance between 12 and 1, (or 12 and 2, or 1 and 2, &c.) will be the same, at equal Distance from the Center of your Dial, whether it be drawn by the *Equinoctial Dial*, or by Scales, or by Tables.

Then

Then out of the Dialling Scale take the whole Length of the Scale of *Hours* with the Compasses ; and setting one Foot of the Compasses in *e*, with the other make an Arch crossing the Line *NS* toward *S* ; and then do the like on *w*. From the Point *x* of the Line *NS*, where the two Arches (||) cross one another, draw the Lines *x e* and *x w* ; which will be of an equal Length with the Scale of Hours in the Dialling Scale : from which Hour-scale the several Hours (and the intermediate Spaces) are to be respectively transferred unto the Lines *x e* and *x w*. Lines drawn from *C* to the several Hour-points on the Lines *x e* and *x w*, will be the respective Hour lines. And so the Dial is finished by the Scale : for the Hour-lines before 6 in the Morning, and after 6 in the Evening, are to be had, as afore.

If you would work by Dialling
Tables, having drawn the Lines *NS*

8.
*To draw
an Horizontal
Dial by
Dialling
Tables.*

(1) If the Lines drawn by the Compasses, set upon *e* and *w*, do not cross one the other exactly in some Point of the *Meridian NS*, then some Fault has been made in setting off the said Lines, and the Work must be repeated, till they do thus cross.

(C 2)

and

and EW to what Length you please, upon C the Interfection of the said Lines draw a Semicircle *e s w*, as in *Fig. 3*. Then on the said Semicircle set off the Degrees and Minutes answering to each Hour (and each Quarter, Half, or three Quarters of an Hour) in the Table for *Horizontal Dials*. After which draw the Hour-lines from C to the several Hour-points in the said Semicircle. The Substyle and Style are found, as afore.

Having shewn, how to draw an *Horizontal Dial* three several Ways, it remains now to shew how to *place aright* the said Dial, when drawn; and this will be best spoken of together with the placing of other Dials, *Chap. 5*.

C H A P. III.

Of an (*) Erect Direct South and North Dial.

THE Erect Direct South Dial shall be spoken of next, as being next to the *Horizontal* Dial the most useful: forasmuch as it shews the Time of the Day from 6 to 6 throughout the whole Year.

This Sort of Dial is drawn after the same manner, by the Help of the *Equinoctial*, as the *Horizontal* Dial, excepting the Particulars following; viz. First, That the *Meridian* or 12 a Clock Line, (which in this, as well as the *Horizontal* Dial, is always the Substyle,) forasmuch as it must be so placed as that one of its Ends must Point to the (†) *Zenith*, the other to

1.
A Direct South Dial the most useful next to an Horizontal Dial.

2.
To draw a Direct South Dial, by the Help of the Equinoctial Dial.

(C 3)

the

(*) Inclining and Reclining Dials being seldom used, hence these Dials are frequently stiled only Direct South and North Dials.

(†) The *Meridian* of any Place or Dial, as it passes through the North and South Poles, so it passes likewise

Of a Direct South Dial.

the *Nadir*, may therefore be most properly here denoted by ZN. Secondly, the Style CP must be erected upon the Substyle ZN, so as to make therewith an Angle equal (not to the Elevation of the Pole, as in an *Horizontal* Dial; but) to the Complement of the Pole's Elevation. For such is the Measure of the Angle, which the (||) South Pole, represented by the Style of this Dial, makes with the Plane of the Prime Vertical. Now the Elevation of the Pole above the *Horizon* of London being $51\frac{1}{2}$ Degrees, its Complement is $38\frac{1}{2}$ Degrees. Thirdly, On this Dial there need be inscribed no Hour, either before 6 in the Morning, or after 6 in the Evening; for the Plane of this

wise through the Zenith and *Nadir* of the said Place. In an *Horizontal* Dial the *Meridian* Line is to be placed with its Ends towards the North and South Points, and therefore is therein fitly denoted by NS. But in a Direct South Dial, the *Meridian* Line is to be placed so, as that its Ends may Point to the Zenith and *Nadir*, and therefore is here more fitly denoted ZN.

(||) This may be evidently represented to the Eye by the Dialling Sphere; and consequently the Reason why the End P of this Style must be placed downwards,

Of a Direct North Dial.

23

Dial representing the south Side of the Plane of the Prime Vertical, the Sun never Shines upon it before 6 in the Morning, or after 6 in the Evening. See Fig. 4.

If you work (not by the Equinoctial Circle or Dial, but) by a Dialling Scale, then (besides the fore-mentioned Particulars, wherein the drawing of this Dial differs from drawing an Horizontal Dial) it is also to be known, that upon the Line E W, from C towards E and W, must be set off the Extent (taken from the Scale of Latitude; not of the Latitude itself, but) of the Complement of the Place's Latitude. See Fig. 5.

3.
To draw a
Direct
South
Dial by a
Dialling
Scale.

If you work by Tables, then the Degrees of the Angle, which every Hour-line makes with Z N the Meridian or Substyle, must be taken from the Table for a Prime Vertical or Direct South Dial. See Fig. 6.

4.
To draw
the same
by Dialling
Tables.

A Direct North Dial differing from a Direct South Dial primarily in this alone, that the former represents the north Side of the Plane of the Prime Vertical, and the latter the south Side; hence the drawing of a Direct

3.
To draw a
Direct
North
Dial.

(C 4)

North

North Dial is the same, as of a Direct South Dial; excepting 1st, that the Hours requisite to be inscribed on this Dial in our Country are no more than these, viz. 4, 5, 6 in the Morning, and 6, 7, 8 in the Evening. For the Sun with us never rises till after 3 in the Morning, and always sets before 9 in the Evening; and from 6 in the Morning till 6 in the Evening it turns off from the North to the south Side of the Plane of the Prime Vertical. 2^{dly}, Forasmuch as the Style of this Dial represents the north Segment of the Axis, and so its End P represents the north Pole therefore the End P must be placed looking upwards toward the north Pole. And consequently, that End of the Substyle, which answers to the End P of the Style, must Point towards the *Zenith*, and therefore is here properly to be denoted by Z, and the other End of the Substyle by N, as answering to the *Nadir*, contrary to the Position and Notation of them in a Direct South Dial. See Fig. 7.

Of a Direct North Dial.

25

As to the Placing of a Direct South or North Dial, it will be more conveniently spoken of Chap.

5.

West Dial.

I. To draw a Direct North Dial, first draw a horizontal line, and then draw a vertical line perpendicular to it, meeting it in the middle. The point where the lines meet is the North Point, and is to be denoted by N. The other end of the line is to be denoted by S, as representing the South Point of the Dial. The line N-S is to be divided into 12 equal parts, and the points of division are to be denoted by the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, beginning from the North Point, and going towards the South Point. The line N-S is to be extended both ways, and the points of extension are to be denoted by the numbers 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223, 224, 225, 226, 227, 228, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 241, 242, 243, 244, 245, 246, 247, 248, 249, 250, 251, 252, 253, 254, 255, 256, 257, 258, 259, 260, 261, 262, 263, 264, 265, 266, 267, 268, 269, 270, 271, 272, 273, 274, 275, 276, 277, 278, 279, 280, 281, 282, 283, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313, 314, 315, 316, 317, 318, 319, 320, 321, 322, 323, 324, 325, 326, 327, 328, 329, 330, 331, 332, 333, 334, 335, 336, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 354, 355, 356, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381, 382, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 400, 401, 402, 403, 404, 405, 406, 407, 408, 409, 410, 411, 412, 413, 414, 415, 416, 417, 418, 419, 420, 421, 422, 423, 424, 425, 426, 427, 428, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 439, 440, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, 455, 456, 457, 458, 459, 460, 461, 462, 463, 464, 465, 466, 467, 468, 469, 470, 471, 472, 473, 474, 475, 476, 477, 478, 479, 480, 481, 482, 483, 484, 485, 486, 487, 488, 489, 490, 491, 492, 493, 494, 495, 496, 497, 498, 499, 500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 516, 517, 518, 519, 520, 521, 522, 523, 524, 525, 526, 527, 528, 529, 530, 531, 532, 533, 534, 535, 536, 537, 538, 539, 540, 541, 542, 543, 544, 545, 546, 547, 548, 549, 550, 551, 552, 553, 554, 555, 556, 557, 558, 559, 560, 561, 562, 563, 564, 565, 566, 567, 568, 569, 570, 571, 572, 573, 574, 575, 576, 577, 578, 579, 580, 581, 582, 583, 584, 585, 586, 587, 588, 589, 590, 591, 592, 593, 594, 595, 596, 597, 598, 599, 600, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 614, 615, 616, 617, 618, 619, 620, 621, 622, 623, 624, 625, 626, 627, 628, 629, 630, 631, 632, 633, 634, 635, 636, 637, 638, 639, 640, 641, 642, 643, 644, 645, 646, 647, 648, 649, 650, 651, 652, 653, 654, 655, 656, 657, 658, 659, 660, 661, 662, 663, 664, 665, 666, 667, 668, 669, 670, 671, 672, 673, 674, 675, 676, 677, 678, 679, 680, 681, 682, 683, 684, 685, 686, 687, 688, 689, 690, 691, 692, 693, 694, 695, 696, 697, 698, 699, 700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718, 719, 720, 721, 722, 723, 724, 725, 726, 727, 728, 729, 730, 731, 732, 733, 734, 735, 736, 737, 738, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 749, 750, 751, 752, 753, 754, 755, 756, 757, 758, 759, 760, 761, 762, 763, 764, 765, 766, 767, 768, 769, 770, 771, 772, 773, 774, 775, 776, 777, 778, 779, 780, 781, 782, 783, 784, 785, 786, 787, 788, 789, 790, 791, 792, 793, 794, 795, 796, 797, 798, 799, 800, 801, 802, 803, 804, 805, 806, 807, 808, 809, 810, 811, 812, 813, 814, 815, 816, 817, 818, 819, 820, 821, 822, 823, 824, 825, 826, 827, 828, 829, 830, 831, 832, 833, 834, 835, 836, 837, 838, 839, 840, 841, 842, 843, 844, 845, 846, 847, 848, 849, 850, 851, 852, 853, 854, 855, 856, 857, 858, 859, 860, 861, 862, 863, 864, 865, 866, 867, 868, 869, 870, 871, 872, 873, 874, 875, 876, 877, 878, 879, 880, 881, 882, 883, 884, 885, 886, 887, 888, 889, 890, 891, 892, 893, 894, 895, 896, 897, 898, 899, 900, 901, 902, 903, 904, 905, 906, 907, 908, 909, 910, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929, 930, 931, 932, 933, 934, 935, 936, 937, 938, 939, 940, 941, 942, 943, 944, 945, 946, 947, 948, 949, 950, 951, 952, 953, 954, 955, 956, 957, 958, 959, 960, 961, 962, 963, 964, 965, 966, 967, 968, 969, 970, 971, 972, 973, 974, 975, 976, 977, 978, 979, 980, 981, 982, 983, 984, 985, 986, 987, 988, 989, 990, 991, 992, 993, 994, 995, 996, 997, 998, 999, 1000.

or a North Dial.

C H A P. IV.

Of an (*) Erect Direct East or West Dial.

1. *To draw a Direct East Dial.* **I** Begin with a *Direct East Dial*, whose Plane represents the east Side of the Plane of the Meridian. Now to draw this Dial, there must be first drawn an *Horizontal Line*, i. e. a Line representing the *Horizon*, or running Parallel to it, and so level. One End of this Line will represent the north Point of the *Horizon*, and may therefore be fitly denoted by N; and the other End by S, as representing the south Point of the *Horizon*. See Fig. 8.

2. *To find the Substyle.* Taking any Point C toward S, the south End of the Line N S for a Center, describe an Arch toward N; and upon that Arch set off the Height P of the Pole, and draw the Line C P for the Substyle.

(*) These also are frequently stiled only *Direct East* or *West* Dials,

Having

Having found the Substyle, draw thereon the Contingent Line T G; and then proceed to draw an (+) *Equinoctial* Dial, taking any point *Æ* in the Substyle for the Center of the said *Equinoctial* Dial. That Diameter of the Semicircle (representing Half the *Equinoctial* Circle,) which runs Parallel to the Contingent, is here the *Meridian* of the *Equator*; from which you are to begin to divide the Semicircle into Hours, or into 6 equal Parts, each containing 15 Degrees. Through each of these Divisions of the *Equinoctial* Semicircle draw Lines from *Æ* to the Contingent; and again through each Point of the Contingent, whereon the said Lines fall, draw other Lines (||) parallel to the Substyle. These last will be the Hour-lines; that which falls in with the Substyle C P being always the 6 a

3.
To draw
the Hour-
lines,

(+) There is no Mention made of drawing a Direct East or West Dial by *Scales* and *Tables*, because it is in Effect done both Ways, by the Help of the *Equinoctial* Dial.

(||) Because the Axis of the World runs parallel to the Plane of the *Meridian*, (as may be shewn by the Dialling Sphere,) and so must be conceived to cast its Shade parallel also to it self.

Clock

Clock Line; those above it the Hour-lines of the Hours before 6, and those below it the Hour-lines of the Hours after 6. Where it is to be noted, that as 4 and 5 are the only Hours before 6, which need be inscribed on this Dial; because the Sun never rises to us till after 3; so the Hours to be inscribed on this Dial after 6, are no more than 7, 8, 9, 10, and 11; forasmuch as this Dial-plane representing the Plane of the *Meridian*, the Sun shines not upon its Surface, but upon its south Side or Edge, at 12 a Clock.

4.
To place
the Style.

The Hour-lines being drawn, the Style is to be placed (*) parallel to the Substyle CP, and so far distant from it, as the Center *Æ* of the *Equinoctial* was taken distant from the Contingent. And so the Dial is Finished; as *Fig. 8.*

(*) Because the Style represents the Axis of the World, which runs parallel to the Plane of the *Meridian*. Hence Direct East and West Dials have no Centers, through which the Axis passes, and from which consequently are to be drawn all the Hour-lines, as in *Horizontal* and Direct South and North Dials; which are therefore called *Central Dials*.

A Direct West Dial differing from a Direct East Dial primarily in this alone, that the former represents the west Side of the Plane of the Meridian, and the latter the east Side; hence the Drawing of a Direct West Dial, is the same with that of a Direct East Dial, excepting only the different Denominations of the Hours to be inscribed on this Dial, viz. 1 to 8 in the Afternoon; which must be placed respectively from 6, (the Hour-line whereof always falls in with the Sub-style,) as the Morning Hours are in a Direct East Dial. See Fig. 9.

How these Dials, when drawn, are to be placed, so as to have a due Situation in respect of the Heavens, is shewn in the following Chapter.

5.
To draw a
Direct
West Dial.

CHAP.

C H A P. V.

Of duly placing a Direct (East, or West, North, or South,) Dial; and of the Manner of finding, whether a Wall has a Direct or Declining Position or Situation.

I.
A Dial is then duly placed, when its Plane answers to the Plane of the Celestial Circle, which it represents. In order whereto the Dial-plane must be placed parallel to its respective Celestial Plane.

EVERY Dial-plane representing the Plane of some Circle in the Heavens, therefore, when any Dial is drawn, that it may go true, it is requisite that its Plane be so placed, as to answer exactly to the Plane of the Celestial Circle, which it represents. Wherefore, if it be an *Horizontal* Dial, its Plane must be placed *Horizontally*, or parallel to the *Horizon*, i. e. exactly level. If it be any *Vertical* Dial, (as a *Direct North* or *South, East* or *West* Dial,) it must be placed *Vertically*, i. e. perpendicular to the *Horizon*, or exactly *Upright*. Now the Instrument represented, *Fig. 10.* will shew, when any of the fore-mentioned

mentioned Dials are thus duly placed. Namely, if, when the Side H N of the said Instrument be applied to the *Horizontal Dial*, the String falls exactly on the perpendicular Line P P, then the Dial is placed *Horizontally*, or truly Level; otherwise it is not, but must be altered, till the String does exactly fall on the said Perpendicular. In like manner, if, when the Side Z N or Z H be applied to a *Vertical Dial*, the String exactly falls on the Perpendicular P P, then the Dial is placed *Vertically*, or truly Upright; otherwise it is not, but must be altered till the String does so fall.

Again, an *Horizontal Dial* must be placed, not only *Horizontally* in general, but also so, as that the four Cardinal Points of the Dial may respectively answer the like Cardinal Points of the *Horizon*. In like manner *Vertical Dials* must be placed, not only in general *Vertically*, but also so, as that the Plane of each *Vertical Dial* may be parallel or answer to the Plane of that *Vertical Circle* in the Heavens, which it particularly has respect to. Thus the Plane of a *Direct South or North Dial* must be

2.
And also,
The Cardinal
Points of
the Dial-
plane must
answer to
the Cardinal
Points
of its re-
spective Ce-
lestial
Plane.

be so placed, as that it may be parallel to the Plane of the Prime Vertical, which it represents, and that it may respectively answer to the South or north Side of the said Plane of the Prime Vertical. In like manner, the Plane of a Direct East or West Dial must be so placed, as that it may be parallel to, or fall in with the Plane of the *Meridian*, which it represents; and that it may respectively answer to the east or west Side of the said *Meridian* Plane.

3.
To find the
Meridian
Line of
any Plane
or Place.

Now in Order thus to place aright any of the fore-mentioned Dials, it is requisite to find where the *Meridian* crosses the Place, on which you would put the Dial. And this may be done several Ways. The most easy is by the Help of (what is called) the Mariners Needle, supposing it has none, or but little Variation in the Place where you are. For then the *Meridian* runs over, or parallel to the Length of the said Needle. Another Way is by holding up a String, when the Sun is in its *Meridian* Altitude, (which is to be found by the Quadrant,) for then the Shade of the String will represent the *Meridian* Line

of the Place where you are. Another Way, somewhat longer, but much surer, is this: Any Time in the Morning, when the Sun shines, erect any Pin or straight Piece of Iron or Wood, and mark where the End of its Shade falls. See *Fig. 11*:

Then on the Point, where the Pin was erected, as on a Center, draw a Circle passing through the other Point, where the End of the Pin's Shade fell. After which erecting the Pin again where it was, wait till the End of the Pin's Shade touches the Circle in some other Point. The Arch between the two Points of the Circle, on which the End of the Pin's Shade fell at the two several Times, being bisected or divided exactly in Half, a right Line drawn from the Center of the said Circle (*i. e.* from the Point where the Pin was erected) through the Point of Bisection will be the *Meridian* Line of the Place where you are.

The *Meridian* Line of the Place 4.
where you are, being thus found out by one or more of the fore-mention-
ed Ways, an *Horizontal* Dial is truly

To place as
right an
Horizontal
Dial.

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placed,

Of Placing Dials.

placed, (so as that its Cardinal Points shall answer the like Points of the *Horizon*,) by placing the *Meridian* Line (or, which is the same, the 12 a Clock Line) of the said *Horizontal* Dial exactly upon, or parallel to the *Meridian* Line of the Place where you are. For the *Meridian* Line of the Dial being thus placed upon, or parallel to the *Meridian* Line of the Place, the North and South Points of the *Horizontal* Dial, being no other than the North and South Ends of the *Meridian* Line of the Dial, will answer to the North and South Points of the *Horizon* of the Place, these directly answering to the North and South Ends of the *Meridian* Line of the Place. And the North and South Points of the Dial being thus placed so, as to answer to the said Points of the *Horizon*; the East and West Points of the Dial (if rightly drawn) will likewise answer to the East and West Points of the *Horizon*.

5.
To place
aright a
Direct
East or
West Dial.

The Method of placing aright a Direct North or South, East or West (as well as of an *Horizontal*) Dial does likewise depend on the *Meridi-*

an Line of the Place. For having found this by one or more of the Ways above-mentioned, in order to place aright a direct East or West Dial, all that is to be done, is only this, *viz.* directly upon, or parallel to the said *Meridian* Line of your Place, you must erect the Dial with the Face of it Eastward, if it be a direct East Dial; or Westward, if it be a direct West Dial.

In order to place aright a direct North or South Dial a little more is to be done. Namely, having found the *Meridian* Line of your Place, you must draw another Line crossing the former perpendicularly, which will be the Prime Vertical Line of the Place. Upon which therefore directly, or parallel to it, must be placed the Dial, with the Face of it Southward, if it be a direct South Dial; or northward, if it be a direct North Dial.

6.
To place
aright a
Direct
South or
North
Dial.

Hitherto we have considered Dials, as drawn on *Movable* Planes, or Planes not already Fixed. And on such are usually drawn *Horizontal* Dials. But Vertical Dials, (whether

7.
Of Unmo-
vable or
Fixed
Dial-
planes.

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ther

ther Direct or Declining) are more usually drawn on *Unmovable* or Fixed Planes, namely, on the Sides of some Wall. Wherefore in order to draw a Vertical Dial on a Wall, it is requisite first to know, whether the Wall be a direct East or West, North or South Wall, or a Declining Wall; and if the latter, how great its Declination is.

8.
To know,
when a
Wall is
Direct,
East or
West,
North or
South.

Now there are several Ways delivered in Treatises of Dialling for to do this; but such as require, either a peculiar Instrument called from its Use a *Declinator*, or else the Sun's *Azimuth* to be taken, or both. Wherefore I think the following Method is to be preferred before any other, on Account of its Easiness, and withal Exactness. To the Wall, whose Situation you would know, adjoin a Board so, as that one of its Sides may touch the Wall, and the Surface of the Board may lie *Horizontally*, and fast. Upon the Board thus prepared find the *Meridian* by the last of the three Ways above-mentioned, and draw a Line on the Board representing the same, which therefore

therefore we call the *Meridian Line*. If the *Meridian Line* falls in with, or runs Parallel to your Wall, then it is a direct East or West Wall. If not so, then lay a Quadrant flat upon the said Board, with one of its Sides or Edges applied to the Wall, and its Center at the same Time on the *Meridian Line*. If the other Side falls upon the *Meridian Line* drawn on the Board, then the Wall is a direct North and South Wall, i. e. that Side of the Wall which is toward the Sun and you, directly Faces the South; and the other Side of it consequently Faces directly the North. See Fig: 12.

But if when one Side of the Quadrant is applied to the Wall as afore,
 the other Side does not fall upon the *Meridian Line* on the Board, then it is a declining Wall. And if when the right Side or Edge of the Quadrant is applied to the Wall, the *Meridian Line* of the Board is beyond, or without the other Side of the Quadrant, then the Wall in respect of its south Side declines Eastward, in respect of its north Side Westward;

9.
 To know
 when a
 Wall de-
 clines,

(P 3)

(as

(as *Fig. 14.*) but if the *Meridian* Line of the Board be within the left Side of the Quadrant, then the Wall in respect of its south Side declines Westward, in respect of its north Side Eastward, as *Fig. 14.* On the contrary, if the left Side or Edge of the Quadrant be applied to the Wall, and the *Meridian* Line on the Board be without the right Side of the Quadrant, then the Declination of the Wall in respect of its south Side is Westward, in respect of its north Side Eastward (as *Fig. 15.*); but if the said *Meridian* Line be within the right Side of the Quadrant, then the Declination of the Wall in respect of its south Side is Eastward, and in respect of its north Side Westward, as *Fig. 16.*

10. Having thus found, whether the Wall declines Eastward or Westward, it remains to find, how great its Declination is. Now, as when, one Side of the Quadrant being duly applied (as afore) to the Wall, the other Side falls exactly upon the *Meridian* Line of the Board, the Wall has no Declination; so when the other

To find the
Degrees of
Declinati-
on.

Of finding the Situation of Walls. 39.

other Side of the Quadrant does not fall exactly upon the said *Meridian* Line, then the Number of Degrees contained in the Angle made by the said other Side of the Quadrant, and the said *Meridian* Line is the Measure of the Declination. Wherefore as often as the said *Meridian* Line falls within the Quadrant, the Number of Degrees intercepted between the said *Meridian* Line, and that Side or Edge of the Quadrant which is not applied to the Wall, is the Measure of the Wall's Declination. But if the *Meridian* Line falls without the Quadrant, then having drawn on the Board a Circle, with a Ray equal to that of the Quadrant, and upon that Point of the *Meridian* Line whereon you place the Center of the Quadrant, as the Center of the said Circle, thereupon take with the Compasses the Distance between the *Meridian* Line, and that Edge of the Quadrant, which is not applied to the Wall: The said Distance applied to the Division of the Quadrant into 90 Degrees, will thereby shew the Measure of the Wall's Declination.

(D 4)

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II.
Illustration
on by Ex-
amples,

All that has been afore said, is illustrated by (*) *Fig. 12, 13, 14, 15, and 16.* In each of which the Line *ML* denotes the *Meridian Line*; the Line *EW* denotes the Plane of the Prime Vertical, or (which comes to the same) the Plane of a direct South Wall or Dial; and consequently *E* denotes the true East Point, *W* the true West Point. *ESW* the south Side of the Plane of the Prime Vertical, or a direct South Wall; *ENW* the north Side of the Plane of the Prime Vertical, or a direct North Wall: the Line *DC* denotes a declining Wall. Wherefore it is evident, that in *Fig. 12.* one Edge of the Quadrant being duly applied to *EW* the Wall, on the south Side of it *ESW*, the other will fall upon the *Meridian Line*, *ML* drawn on the Board; and thereby shew, that the said Wall *EW* has no Declination. But in *Fig. 13.* the right Edge

(*) From all these Figures it is evident, that the Declination of a Wall or Dial, is the Arch *WD* or *EC* of the *Horizon* intercepted between the Plane of the Prime Vertical, and of the Wall or Dial.

38 Declination of Walls. 70

44

of the Quadrant being applied to D C the declining Wall, and the *Meridian* Line M L falling within the other Side of the Quadrant, thereby is shewn, that the Wall declines westward, and also that the Measure of the Declination is 20 Degrees, this being the Number of the Degrees intercepted between the left Side of the Quadrant, and the *Meridian* Line M L. In *Fig. 14.* the right Edge of the Quadrant being applied to D C the Wall, and the *Meridian* Line M L falling without the left Edge of the Quadrant, I take with my Compasses, on a Circle described as above directed, the Distance between M L the *Meridian* Line, and the left Edge of my Quadrant, and applying the same to the Division of the Quadrant into 90 Degrees, I find the Measure of the said Distance to be 20 Degrees; which consequently is the Measure of the Declination of the Wall D C eastward. And after the same Manner, the fore-mentioned Method of finding the Declination of a Wall may be illustrated in all other Respects.

Having

Having thus shewn how to find the Declination of a Wall, it remains only to shew how to draw a Dial upon a declining Plane or Wall.

CHAP.

C H A P. VI.

Of drawing a Declining Dial.

THE principal Difficulty in drawing a Declining Dial, is in finding the Distance of the Substyle from the *Meridian* or 12 a Clock Line, and the Height of the Style above the Substyle. Now to remove this Difficulty, there is adjoined to the End of this Chapter, a Table shewing the said Particulars, answerable to any Degree of Declination, and which will serve for most Parts of *England*.

I.
The chief
Difficulty
in drawing
a Declining
Dial.

Having then drawn (as in a Direct South or North Dial) two Lines crossing each other perpendicularly, one Z N representing the *Meridian*, the other E W representing the Prime Vertical, if you work by dialling Tables, turn to the said Table (*viz.* Tab. III.) and see what is the Substyle's Distance from the *Meridian* answerable to the Declination of the

2.
To find the
Substyle
and Style
of a Declining
Dial
by Dialling
Tables.

the Wall, which, supposing the Declination 20 Degrees, will be 15 Degrees, 5 Minutes. Then draw an Arch from ZN to EW, on the west Side of ZN, if the Declination be eastward; and on the east Side, if the Declination be westward. On the said Arch set off from ZN the found Distance of the Substyle, viz. at S in *Fig. 17* and *18*. The Line CS, drawn from C (the Intersection of ZN and EW, and the Center of the Dial) to S, will be the Substyle. Then in the Table see what is the Style's Height answerable to the Declination, v. g. of 20 Degrees, and it is 35 Degrees, 34 Minutes. Set this off from S to P, and draw the Line CP which will shew the Style.

3.
To draw
the Hour-
Lines.

Having found the Substyle and the Style, draw (as afore in an *Horizontal*, and direct South or North Dial), the Contingent Line crossing the Substyle at right Angles in any Point Q: only the Substyle ES being here different from the *Meridian* ZN, mark the Point M of the *Meridian*, where it

it is crossed by the Contingent. Then taking (as afore in the other Dials) the Point $\mathcal{A}$ in the Substyle for the Center of an *Equinoctial* Dial, draw a (*) Semicircle; one Half of it being on one Side of the Substyle, and the other Half on the other Side. After which draw the Line $\mathcal{A}M$ cutting the *Equinoctial* Semicircle in M . The Line $\mathcal{A}M$ will be the *Meridian* of the *Equinoctial* Dial, from which you are to begin to divide on each Side the *Equinoctial* Semicircle into *Hours*, or six equal Parts. Lines drawn from $\mathcal{A}$ through the said Divisions to the Contingent will be the *Equinoctial*

(*) It is to be observed, that in Declining Dials the entire Semicircle must be drawn; and it is not sufficient to draw only one Half of the Semicircle as in Direct South and North Dials, forasmuch as the *Meridian* or 12 a Clock Line of the *Equator*, not falling in with the *Meridian* or 12 a Clock Line of the Declining Dial, (as it does in Direct North and South Dials,) hence the Divisions on each Side the 12 a Clock Line of the *Equinoctial*, will not cut the Contingent at equal respective Distances, as in Direct North and South Dials.

Hours.

Hours. And consequently Lines drawn from C the Center of the declining Dial to the same Points of the Contingent, whereon the *Equinoctial* Hour-lines fall, will be the Hour-lines for the declining Dial, (as afore in an *Horizontal* and Direct North or South Dial,) and so the Dial will be finished. See *Fig. 17. and 18.*

4.
The Con-
clusion.

And thus I have gone through those Elements of Dialling, which I judge most requisite to be known by Young Gentlemen, at least at their first Institution in the said Arts or Sciences. What follows, are such *Dialling Tables* as are requisite to this Treatise; which though calculated indeed for the Latitude of *Oxford*, (*viz.* 51 Degrees, 45 Minutes,) yet will serve without any sensible Difference for most Parts of *England*. The *Dialling Scales*, or rather the Way of drawing dialling Scales, *viz.* the Lines or Scales of *Latitude* and of *Hours*, (both mentioned and made use of in this Treatise) as also of *Inclination of Meridians*,

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is represented**

T A B.

T A B. I.
Shewing what Angle every Hour line, (as also Quarter, Half, and three Quarters of an Hour) makes with the Meridian or twelve a Clock Line, in an Horizontal Dial.

Hours.	Degrees.	Minutes.
12	00.	00.
1	02.	57.
2	05.	54.
3	08.	52.
11	11.	53.
1	14.	55.
2	18.	01.
3	21.	10.
10	24.	23.
1	27.	41.
2	31.	04.
3	34.	33.
9	38.	09.
1	41.	51.
2	45.	40.
3	49.	36.
8	53.	40.
1	57.	53.
2	62.	11.
3	66.	37.
7	71.	09.
1	75.	38.
2	80.	29.
3	85.	14.
6	90.	00.

T A B. II.
Shewing the like Angles in a Direct South or North Dial.

Hours.	Degrees.	Minutes.
12	00.	00.
1	02.	19.
2	04.	40.
3	07.	01.
11	09.	25.
1	11.	52.
2	14.	23.
3	16.	58.
10	19.	40.
1	22.	28.
2	25.	24.
3	28.	30.
9	31.	46.
1	35.	13.
2	38.	54.
3	42.	49.
8	47.	00.
1	51.	27.
2	56.	13.
3	61.	15.
7	66.	36.
1	72.	11.
2	77.	00.
3	83.	58.
6	90.	00.

T A B.

Shewing the Distance of the Substyle from the Meridian, and the Height of the Style above the Substyle; answerable to the several Degrees of Declination:

Declination.	Substyle's Distance from the Meridian.	Style's Height above the Substyle.
Degrees.	Degrees. Minutes.	Degrees. Minutes.
1	0 48	38 14
2	1 48	38 13
3	2 48	38 11
4	3 48	38 8
5	3 48	38 5
6	4 48	38 0
7	5 48	37 55
8	6 48	37 49
9	7 48	37 42
10	7 48	37 34
	(E)	Declination

Declination.	Substyle's Distance from the Meridian.		Style's Height above the Substyle.	
	Degrees.	Minutes.	Degrees.	Minutes.
11	8 .	33	37 .	26
12	9 .	18	37 .	16
13	10 .	2	37 .	6
14	10 .	48	36 .	55
15	11 .	32	36 .	45
16	12 .	15	36 .	31
17	12 .	59	36 .	18
18	13 .	41	36 .	2
19	14 .	24	35 .	50
20	15 .	5	35 .	34
21	15 .	47	35 .	19
22	16 .	27	35 .	2
23	17 .	7	34 .	44
24	17 .	47	34 .	26
25	18 .	15	34 .	8
26	19 .	4	33 .	49
27	19 .	41	33 .	29
28	20 .	19	33 .	8
29	20 .	55	32 .	47
30	21 .	31	32 .	25
31	22 .	6	32 .	3
32	22 .	40	31 .	40
33	23 .	14	31 .	17
34	23 .	47	30 .	53
35	24 .	19	30 .	28

Decli-

T A B. III.

52

Declination.	Substyle's Distance from the Meridian.		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
36	24. 51	52	30. 58	3
37	25. 51	23	29. 58	36
38	25. 51	53	29. 58	12
39	26. 51	23	28. 58	45
40	26. 51	52	28. 58	18
41	27. 51	21	27. 58	51
42	27. 51	49	27. 58	23
43	28. 51	16	26. 58	55
44	28. 51	42	26. 58	26
45	29. 51	8	25. 58	57
46	29. 51	33	25. 58	29
47	29. 51	58	24. 58	58
48	30. 51	22	24. 58	28
49	30. 51	45	23. 58	58
50	31. 51	8	23. 58	27
51	31. 51	30	22. 58	56
52	31. 51	51	22. 58	24
53	32. 51	12	21. 58	52
54	32. 51	32	21. 58	20
55	32. 51	51	20. 58	48
56	33. 51	10	20. 58	15
57	33. 51	28	19. 58	42
58	33. 51	46	19. 58	9
59	34. 51	3	18. 58	35
60	34. 51	19	18. 58	2

(E 2)

Decl.

Declination.	Substyle's Distance from the Meridian.	Substyle's Height above the Substyle.
Degrees.	Degrees. Minutes.	Degrees. Minutes.
61	34.08	85
62	34.08	50
63	35.08	85
64	35.88	89
65	35.88	82
66	35.78	46
67	35.78	58
68	36.08	80
69	36.08	21
70	36.78	32
71	36.78	42
72	36.48	51
73	37.48	21
74	37.48	19
75	37.48	17
76	37.88	25
77	37.88	22
78	37.48	37
79	37.48	44
80	37.48	50
81	37.08	54
82	37.08	59
83	38.08	42
84	38.08	6
85	38.08	9
Declination.	(23)	Declination.

Declination.	Substyle's Distance from the Meridian.		Style's Height above the Substyle.	
Degrees.	Degrees.	Minutes.	Degrees.	Minutes.
86	38.	11	2.	29
87	38.	13	1.	52
88	38.	14	1.	12
89	38.	14	0.	37
90	38.	15	0.	0

Several Dignities of Dial
and other Cuts, belong-
ing to this Treatise

Fig. 1. A N Horizontal Dial
drawn by the Help
of the Equinoctial Dial.
2. An Horizontal Dial drawn
by the Help of dialling Scales.
3. An Horizontal Dial drawn
by the Help of Dialling Tables.
4. A Direct South Dial drawn
by the Help of the Equinoctial
Dial.

CATALOGUE

OF THE

Several Draughts of Dials,
and other Cuts, belong-
ing to this Treatise.

Fig. 1. **A** N Horizontal Dial
drawn by the Help
of the Equinoctial Dial.

2. An Horizontal Dial drawn by the Help of dialling Scales.

3. An Horizontal Dial drawn by the Help of Dialling Tables.

4. A Direct South Dial drawn by the Help of the Equinoctial Dial.

5. A

5. A Direct South Dial drawn by the Help of Scales.

6. A Direct South Dial drawn by the Help of Tables.

7. A Direct North Dial.

8. A Direct East Dial.

9. A Direct West Dial.

10. The Draught of an Instrument, whereby to find, whether a Dial-plane be truly Horizontal, or Erect.

~~11. The Draught of the most exact Method for finding the Meridian of a Place or Dial-plane.~~

12, 13, 14, 15, 16. Several Draughts representing the Method to find whether a Wall be Direct or Declining; and if declining, how many Degrees it has of Declination.

17. A Dial declining Westward 20 Degrees.

18. A Dial declining Eastward 20 Degrees.

19. The

1. The Geometrical Way of
drawing Lines, and Scales of Hours,
of Altitudes, and Azimuths, Declin-
ation, or (which is the same) of Chords. Book I. 7.

2. The Geometrical Way of
drawing a Line, or Circle of the
Inclination of Meridians. Book II. 10.

3. Whether to find, whether a
Dial-plane be truly Horizontal, or
Erect. Book III. 11.

4. The Draught of the map
Exact Method for finding the Me-
ridian of a Place or Dial-plane. Book IV. 12.

5. Several
Draughts, and the Method
to find whether a Dial-plane be Direct
or Declining, and how many Degrees
Declination. Book V. 13.

6. A Dial declining West-
ward 20 Degrees. Book VI. 14.

7. A Dial declining East-
ward 20 Degrees. Book VII. 15.

